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A METHODOLOGY FOR COMPARING A STANDOFF WEAPON WITH CURRENT CONVENTIONAL MUNITIONS IN A RUNWAY ATTACK SCENARIO

THESIS

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A METHODOLOGY FOR COMPARING A STANDOFF WEAPON WITH CURRENT CONVENTIONAL MUNITIONS IN A RUNWAY ATTACK SCENARIO

THESIS

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of the Air Force Institute of Technology

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In Partial Fulfillment of the

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Master of Science in Operations Research

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Preface

The purpose of this study was to develop a methodology for comparing current inventory weapons with a standoff weapon in the Offensive Counter Air mission area. The primary hurdle was the development of a simulation model which would accurately represent the interactions between the aircraft, the standoff weapon, and the terminal area threats. This model includes the first attempt to simulate attrition of weapons after release from the aircraft.

There are several people who have contributed significantly to the completion of this thesis. We are indebted to Mr. Jerry Bass of the Air Force Armament Laboratory for his assistance in the use of the Attack Assessment Program. The attrition data provided by Mr. David Cocanougher, also from the Armament Laboratory, proved invaluable in the development of the simulation. We also thank the members of our Thesis Committee, Capt Joseph Litko and Lt Col Joseph Widhalm, for their instruction and support throughout the effort.

Finally, we thank our wives and children whose patience during the long hours devoted to this effort was as important, and sometimes as difficult, as the work itself.

Dennis M. Coulter

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Abstract

This research developed a SLAM discrete-event simulation model to support a methodology for comparing a standoff weapon with current conventional weapons. This study is limited to the defensive threats within a 20 NM terminal area surrounding a generic Warsaw Pact airfield.

The emphasis of the study was simulation of the standoff weapon interactions with the terminal threats. Previous models have not attempted to model the threat reactions to the standoff weapons. The resulting simulation enables the analyst to study the effects of weapon release conditions on weapon attrition, runway damage effectiveness, and aircraft attrition.

ABSTRACT

This research developed a SLAM discrete-event simulation model to support a methodology for comparing a standoff weapon with current conventional weapons. This study is limited to the defensive threats within a 20 NM terminal area surrounding a generic Warsaw Pact Airfield.

The emphasis of the study was simulation of the standoff weapon interactions with the terminal threats. Previous models have not attempted to model the threat reactions to the standoff weapons. The resulting simulation enables the analyst to study the effects of weapon release conditions on weapon attrition, runway damage effectiveness, and aircraft attrition.

A METHODOLOGY FOR COMPARING A STANDOFF WEAPON WITH CURRENT CONVENTIONAL MUNITIONS IN A RUNWAY ATTACK SCENARIO

I. Introduction

General Issue

Weapon research and development is continually producing more accurate, effective, and reliable weapons for use in runway denial. The Air Force has purchased the French developed Durandal weapon as an interim solution to runway attack until the Boosted Kinetic Energy Penetrator (BKEP) completes full-scale engineering development and enters production. These new weapons will enhance runway damage effectiveness through more effective kill mechanisms which improve cratering. Aircraft losses are expected to decrease due to achieving the desired closure probability with fewer sorties. The BKEP is a submunition designed to be carried to the target in a dispenser vehicle. Future dispenser weapons can be designed with the additional capability of being released at long standoff distances from the target. Because of possible attrition of the dispenser when employing this standoff capability, there presently is no way to compare this type of new weapon with munitions currently in the inventory.

The standoff capability allows release from high speed, low-flying aircraft at distances, from the target, of up to twenty nautical miles. This aspect of the standoff weapon is claimed, by munitions developers, to drastically change current terminal area tactics and, more importantly, greatly reduce aircraft attrition by runway area defenses (31). In order to determine if the standoff weapons provide a substantial improvement over current weapons, a methodology for comparing these weapons with conventional tactical weapons is required.

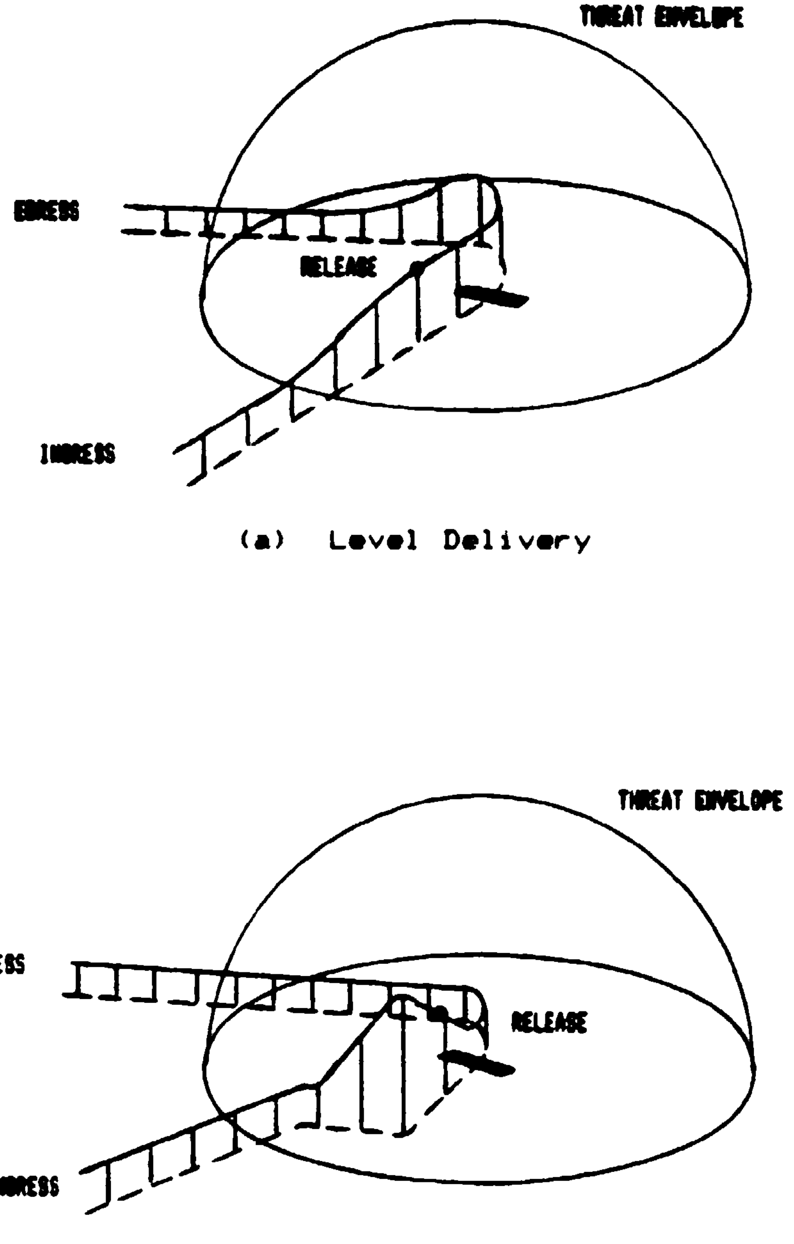
Background

The United States Air Forces in Europe (USAFE) and North Atlantic Treaty Organization (NATO) Allies do not currently possess an effective conventional weapon to deny Warsaw Pact forces the use of runways during a conflict situation (18:2). According to basic doctrine, "the first consideration in employing aerospace forces is gaining and maintaining the freedom of action to conduct operations against the enemy" (10:2-11). Due to limited USAFE/NATO defensive capabilities, the chances for attaining air superiority are diminished without successful accomplishment of Offensive Counter Air (OCA) missions (11:49).

In 1984, the Commander of the Allied Air Forces Central Europe, General Minter, supported the requirement for successful OCA with a statement calling for a runway cratering munition to reduce the number of enemy sorties (18:3). This led to the purchase of the Durandals to provide an increase in our runway attack capability. Limited numbers and employment options prevent Durandal from being a total solution to the problem of denying enemy aircraft a landing and take off surface (18:6). Current OCA missions employ tactics and targeting philosophy developed to deny the enemy the use of maintenance, fuel, ammunition, and other operational facilities. These tactics have resulted from both an increased emphasis on reducing the enemy's capabilities through destruction of other sortie production facilities and from the lack of a suitable munition to attack runways.

The Air Force Armament Laboratory at Eglin AFB studied standoff weapon capabilities in a joint program with the German government (13). This program centered on development of a dispenser weapon capable of delivering a large number of submunitions to a target. The program studied dispenser navigation, pattern generation mechanisms, and several potential submunitions including those designed to crater a runway (29). It also identified emerging technological capabilities that exist in kill mechanisms, navigation accuracy, and wide area target coverage.

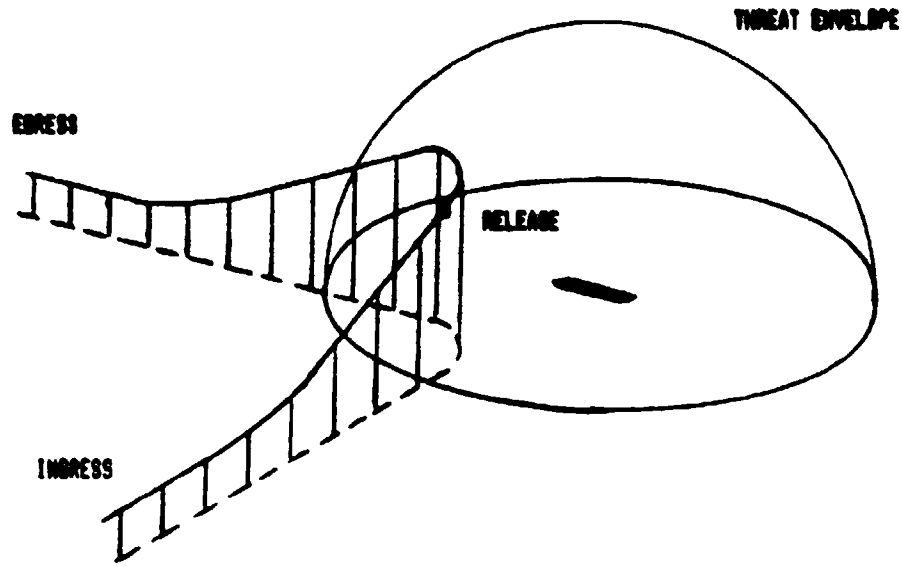
Standoff weapons offer the advantage of reduced attrition of the delivery aircraft in the terminal threat area through weapon release at ranges between five to twenty miles from the target. Figures 1(a), 1(b), and 2(a) represent tactics employed with conventional weapons currently in the inventory: level, dive, and toss. In the



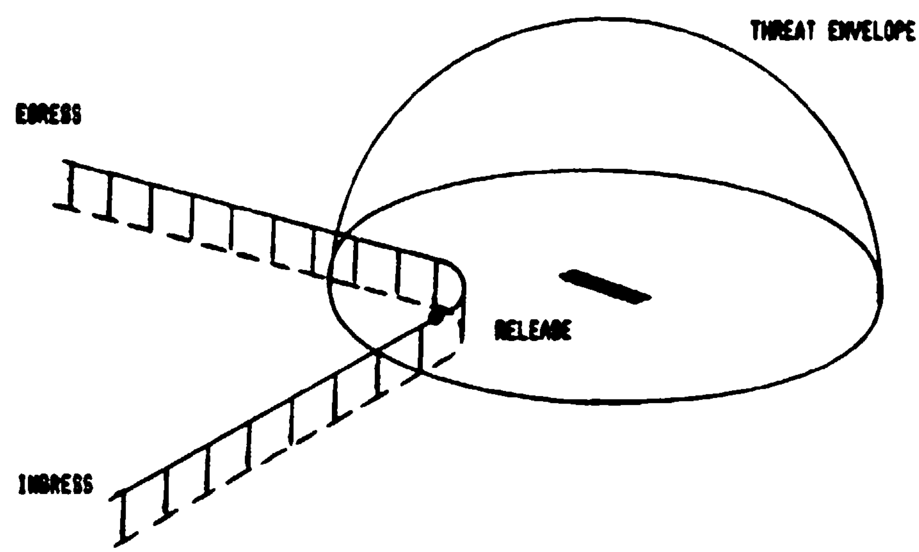
(a) Level Delivery

(b) Low Angle Dive Delivery

Figure 1. Overflight Tactics



(a) Toss Delivery



(b) Standoff Weapon Delivery

Figure 2. Standoff Tactics

first two cases, the delivery aircraft must fly directly over the target to release its weapons. These tactics increase exposure time in the terminal defensive system's envelopes. The toss maneuver, Figure 2(a), avoids overflight of the target and provides a limited degree of standoff capability. This tactic avoids the anti-aircraft artillery (AAA) defenses, but the high altitudes attained during the maneuver are usually in the heart of the surface-to-air (SAM) threat envelopes which results in higher attrition rates compared to low level flight. On the other hand, Figure 2(b) shows a standoff delivery where the aircraft remains at low level and delivers its weapons with minimal or no entry into the terminal threat envelope. This delivery option results in lower aircraft attrition by terminal threats, but leads to the possibility of weapon attrition.

Specific Problem

Current conventional tactics for runway attack require overflight of the target which results in high aircraft attrition. Next generation weapons designed to provide a standoff capability are expected to reduce aircraft attrition. Therefore, a methodology to compare these new weapons with current conventional munitions should be developed. Presently, comparisons are not possible because existing methodologies are not structured to model the interactions of standoff weapons with terminal defenses.

Weapon attrition decreases the number of weapons that reach the target and may be a significant factor in evaluating target damage effectiveness. Also, weapon attrition may affect delivery aircraft attrition estimates due to possible increased sortie requirements.

Objectives of the Research

The objective of the research is to develop a methodology that can be used to compare runway damage effectiveness and aircraft attrition for OCA missions employing either a standoff weapon capability or current conventional tactics. Weapon attrition during flights of up to twenty nautical miles has not been adequately considered in previous methodologies. A model will be developed that incorporates a realistic scenario, damage effectiveness values, and attrition estimates for the delivery aircraft and weapons. Appropriate elements of existing methodologies will be incorporated into the model.

Literature Review

To support the objective of this research, the capabilities of existing models were reviewed for possible incorporation into the methodology. Additional research was then necessary because several important issues were not sufficiently addressed in the previous efforts.

Existing Methodologies. Large-scale simulation models such as TAC Warrior, TAC Repeller, and TAGSEM are currently used to predict effectiveness and attrition values in conflict scenarios (14:4). These many-on-many models require large quantities of input data e.g. radar cross-sections, vulnerable areas, flight profiles, threat deployment, and other similar characteristics of the simulated combat. Sorties is another many-on-many engagement model that simulates the interactions of a flight of aircraft encountering air defense threats. This model was created by Teledyne-Brown and is used in the Air Force Armament Laboratory (AFATL/ENYS) at Eglin AFB to create an attrition data base for over two million combinations of targets, aircraft, and weapons (17). In addition to detailed input data describing the system, models of this magnitude require a great deal of computer time (9). A primary model design objective is the use of aggregated data to simplify input requirements and reduce computational effort. Large scale models are, therefore, too complex to be used in our study. Remaining research into existing methodologies concentrated on smaller models.

In 1980, Pemberton developed a model for targeting runways with conventional weapons (23). The model was designed to provide a targeting scheme for employment of weapons against the hardened runway. Deterministic methods were employed in the model to define optimal aimpoints. The method involved a one-dimensional search along the runway with variations in the number of aimpoints and weapons per aimpoint at each position along the runway. A similar procedure by Hachida (15) in 1982 was used for attack on a runway. Both studies model attacks with individually targeted weapons. This approach is not well suited for our model because of the random pattern of submunitions generated with the standoff weapon. The impact points are more realistically modeled by incorporating applicable probability distributions describing the pattern of submunitions surrounding the aimpoint.

In 1983, Neal and Kizer developed a methodology for evaluating factors and interactions associated with close air support (CAS) missions (22). They used simulation to analyze various levels of the factors with the aircraft kill-to-loss ratio as a measure of merit. Because of the differences between tactics and threats in a CAS mission as opposed to an OCA mission, this model could not be used for our purposes without modification.

The next year, Foley and Gress incorporated some routines found in Neal and Kizer's work that resulted in a model of the OCA mission area (14). They used the two dimensional missile engagement logic in the earlier model and modified it to more accurately represent a three dimensional engagement. Initially, this model was viewed as a strong candidate for our purpose requiring only minor modifications to incorporate modeling of the standoff weapon. After detailed examination of the model's code, it was determined that necessary modifications were more extensive than originally anticipated. Their model uses continuous simulation to define the aircraft relationships to the threats as state variables. With this technique, changes to the state variables are expressed as differential equations.

In order to adapt the Foley and Gress model to our purposes, it would require more than the number of state variables available in the simulation language. Additionally, the computer time required to run a continuous simulation is greater than that of a model using discrete time intervals. The expected small increase in accuracy of a continuous simulation did not justify extensive modification of the Foley and Gress model. Therefore, a continuous simulation was replaced by the discrete-event methodology described in Section IV. Several basic assumptions of the Foley and Gress model have, however been adopted. They pertain mainly to threat definition and aircraft tactics. Finally, their model uses tables from the Joint Munitions Effectiveness Manual (JMEM) to determine weapon effectiveness. Tables do not exist for next-generation munitions such as standoff weapons. This lack of data requires use of another method to produce standoff weapon effectiveness estimates.

To incorporate realistic effectiveness values, a model by Roodhouse and Green was investigated (27). They developed a mini-computer version of the Attack Assessment Program (AAP) used for runway attack modeling. The version they produced included earlier modifications of AAP to include the capability to assess damage effectiveness on other elements of the airfield. The input routines are user friendly and make AAP an effective model for estimating damage effectiveness values.

Input Data Requirements. Although the review of existing models led to identification of routines to incorporate into the methodology, several potential areas of concern were not resolved. Since a standoff weapon is not a part of the current weapons inventory, information on capabilities and effectiveness against a runway target is not available. In order to model the standoff weapon, interviews were conducted with personnel from the Air Force Armament Laboratory (5; 9; 12; 19). These discussions indicated that estimates of standoff capabilities developed during the Low Altitude Dispenser Program should accurately represent current technology. A telephone interview was then conducted with Mr. Dick McRae from Brunswick Corporation (20). The interview resulted in receipt of program proposals for follow-on development efforts which provided sufficient information to satisfy the remaining weapon parameter requirements (30; 31).

The threat estimates of terminal defenses around enemy airfields contained in previous theses were reviewed to insure the most current information was included in this study. Interviews with Foreign Technology Division (FTD) personnel (16) and survivability analysts at Eglin (9) were conducted to confirm the earlier estimates. These interviews provided current insights into enemy threat capabilities that correlated well with most of the values cited in previous theses. The threat deployment and capability estimates contained in Section II reflect an unclassified, but realistic, representation of current Warsaw Pact airfield defenses.

Scope and Limitations

In order to produce a methodology for comparing different weapons employed in an OCA mission and keep the model controllable, several limitations were necessary. These limitations primarily affected the defined threat and the reactions of the target aircraft penetrating the defenses. Considerable effort to reduce the impact of the limitations was necessary as the scope of the project was decreased. A model that uses aggregated data was desired to limit input requirements. A thorough knowledge of the OCA mission was necessary at this stage because of the potential for eliminating important factors.

For the purposes of this study, a generic airfield with associated threat was established. The positions, numbers, and capabilities of the individual SAM and AAA threats were derived from a series of unclassified sources (8; 14; 22). Although the model allows for relocation of each of the threats, the locations remained constant throughout the development of the model. This provided a common base for comparison of weapons, although sensitivity to the locations of the threats was examined during model verification. The study assumes enroute attrition will be the same for all tactics and is limited to terminal area attrition within a twenty nautical mile ring surrounding the target.

Several limitations were placed on modeling of the delivery aircraft and standoff weapon attrition. Parameters relating to the probability of engagement and probability of a kill given an engagement are average values obtained from attrition analysts at Eglin (8). The detailed models used at Eglin to generate the attrition data base require detailed classified information on threat and aircraft capabilities. It was considered by the analyst that this level of effort may produce an insignificant increase in confidence levels for the additional amount of work required to generate the input parameters (9). Based on this presumption and the awareness of possible variations implied in Clausewitz's "fog of war", there has been no attempt to model the detailed interactions between the aircraft and the defenses. Vulnerable area, SAM break effectiveness, lethal radius, and other engagement parameters have all been folded into the assumed probabilities of kill given a launch on the target. Electronic countermeasure capabilities have been modeled as a reduced probability of kill based on a random number characterizing the effectiveness of the jamming. A simulation should be sufficiently detailed to permit valid conclusions (4:9) but as the level of abstraction becomes lower the cost of the effort increases (7:23). It is therefore reasonable to limit the degree of detail to an appropriate and sufficient cost and energy level. Comparisons with the outputs of detailed models simulating similar scenarios should provide validation of the aggregated parameters.

The complexity and unpredictability of terrain and weather effects required further simplifications. Weather was not considered in the model because the effects of weather are not easily quantified. This still provides a means for comparison of different weapons although limited to a clear-air mass scenario. Terrain factors are also hard to define, but play a significant role in the engagement of low flying targets. Therefore, this factor was modeled as a variation on the maximum engagement range of the SAM threats.

Methodology

The choice of model structure must be based, not only on the desired output, but also on the time and resources available. Models can be classified according to Table 1.

Table I

Categories of Models

ANALYTICAL
COMPUTER
PEOPLE AND COMPUTERS
PEOPLE
VERBAL

Analytical models, e.g. linear and dynamic programming, usually deal with the general situation and do not represent a particular realization of the situation. Use of these models is often aided by the application of computers, but only after most of the work has been accomplished (26:223). If the interactions between the elements of the system are too complex and a pure analytical solution too cumbersome, a computer model is written to study the particular problem numerically. A computer model gives the flexibility to exercise the model and arrive at values of the output variables for a range of input conditions. These first two categories are classified as mathematical models. Each of the other categories of models require human interactions as an integral portion of the effort (26:223). This limits the use of the models to only those with a knowledge of the system thorough enough to supply inputs during model execution.

The selected methodology must be capable of producing attrition and effectiveness estimates for a variety of potential applications. Each weapon has different capabilities which can be represented by system variables. Once these variables are determined, human interactions are unnecessary. The interactions between the target, the attacking aircraft, and the defensive threats are random; but careful study can produce distributions that accurately reflect the various elements of the system. A mathematical model, therefore, offers the best alternative.

Analytical and computer models fall within the category of mathematical models. The above discussion suggests a strong reliance on computer support to provide the required data within an allowable time frame. Although classic analytical model techniques have been programmed into several computer models, this still does not provide the flexibility and efficiency necessary for the study. Another technique, simulation, has become "... one of the most widely used and accepted tools in operations research and systems analysis..." (4:3) and can be used to produce output values for the desired range of input parameters.

A complex system, such as combat operations, that lacks exact definition of the interactions between its components must have a stochastic representation to account for the random inputs (4:10). Previous simulation efforts have not modeled weapon attrition which must be considered when studying the capabilities of a standoff weapon in the OCA mission area. Therefore, to model the complex scenario with random interactions of multiple weapons and aircraft penetrations into a terminal defense system, simulation has been chosen as the appropriate technique. This simulation will provide the attrition estimates, but effectiveness values will be based on an existing model.

The effectiveness values for various weapons can be derived from the existing AAP model currently used to support weapon effectiveness values found in JMEM (5). AAP has the capability of modeling a variety of weapons including dispenser weapons with random submunition patterns. The model estimates the number of craters on the runway and searches for a clear surface to conduct flying operations. If, for a given replication, the surface does not exist; the runway is considered closed. A series of replications provides estimates of the closure probability for a given tactic and weapon. This study will develop an equation using statistical regression techniques that will evaluate closure probability as a function of attack parameters. AAP will not be a part of the final methodology but will provide the input data to derive the regression equation.

SLAM has been chosen as the appropriate language for the study. SLAM provides the necessary flexibility for the required combination of network structure and discrete event simulation. The network structure allows entities, aircraft and standoff weapons, to flow through the system and Fortran subroutines. As they flow through the system, defensive reactions are simulated and engagement results are calculated. For damage effectiveness, the model will incorporate the effectiveness equations previously derived from AAP data to provide a single model evaluation of effectiveness and attrition.

II. System Structure

Analysis of the Offensive Counter Air (OCA) mission area requires a model that adequately describes the complex interactions between each of the elements within the system. The model must also provide an accurate measurement of effectiveness (MOE) of those interactions. The elements can be divided into three main categories: friendly forces, enemy forces, and uncontrollable forces. When evaluating the various friendly or enemy tactics and weapon systems, the model must be capable of realistically representing the changing characteristics of the different weapons and tactics employed in the scenario modeled.

In this model, the MOEs are the probability of friendly forces closing the enemy's runway after a single attack and the probability that the aircraft are destroyed by the terminal threats. Runway closure is calculated using damage effectiveness (DE) while aircraft attrition is measured with probability of kill (Pk). The associated probabilities for determining DE and Pk are described after the explanation of the system elements and attack scenario.

Friendly Forces

The current Air Force inventory contains a limited array of aircraft and munition combinations that can be effectively employed in the OCA mission area (18). The requirements for the aircraft to be capable of flying high speed, low altitude attacks deep into enemy territory limits the choices among current tactical aircraft. Conventional munition choices are restricted by the ability to effectively crater the target.

<u>Aircraft</u>. For OCA missions, the attack aircraft must have sufficient speed, altitude, range, and navigation capabilities to locate and destroy targets deep in enemy territory. A typical OCA mission profile is shown in Figure 3. The high altitude portions of the mission take advantage of lower fuel consumption to extend the operating range of the attack aircraft. The disadvantage to high altitude flying is that aircraft is more susceptible to enemy defensive systems. So, to increase survivability, a descent to low level is required prior to crossing into enemy airspace.

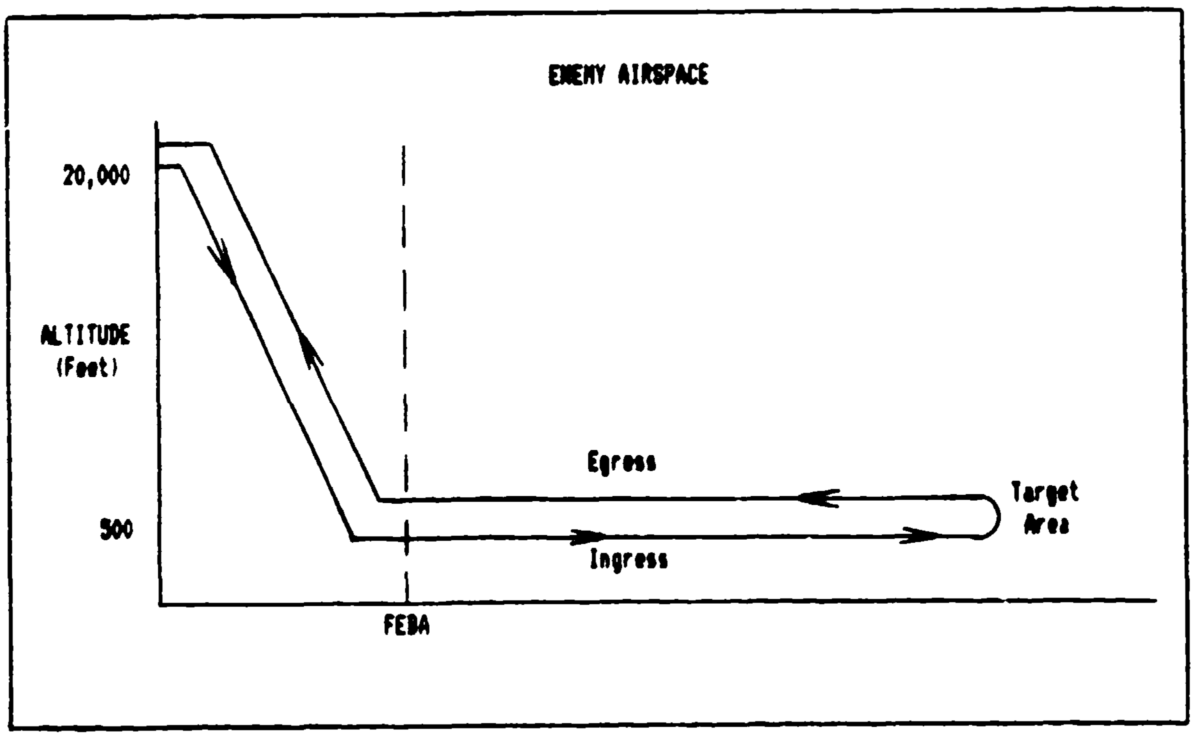


Figure 3. Typical OCA Mission Profile

Of the two altitudes flown, the low level portion is the most difficult. The main reason is that the aircraft must travel at speeds in excess of 500 miles per hour at very low altitudes (less than 500 feet). This tactic reduces enemy detection, but increases the navigational difficulties for both ground avoidance and target acquisition. Sophisticated inertial navigation and radar systems are, therefore, extremely valuable during this portion of the mission.

Currently, the only USAF tactical aircraft with the capability to attack a majority of the targets in the central European theater is the F-111. A second aircraft developed for use in the deep interdiction air-to-ground role is the F-15E. Addition of a second crew station, a ground mapping synthetic aperture radar, and terrain following system into the F-15's avionics have resulted in a capable OCA aircraft. The F-16 is another tactical aircraft with the necessary speed and air-to-ground capability; but, when loaded with a full load of bombs, the F-16 has a very short range capability and, therefore, is not considered a primary OCA aircraft.

Munitions. Weapon selection for OCA missions has always been a difficult task for the tactical forces. Table II lists munitions loadouts on aircraft modeled in this study. In order to deliver sufficient quantities of current inventory weapons to achieve a desired closure probability, multiple sorties must be flown against the target.

Table II

Aircraft Loadouts

Munition Type	Aircraft Loadout	
	F-111	F-15E
General Purpose		
Mk-82	16	12
Mk-84	4	4
I2000	4	4
Runway Attack		
Durandal	10	8
Standoff	4	4

General Purpose. The general purpose weapons require very steep impact angles to cause sufficient damage to the runway surface. Without a steep impact angle these weapons will either breakup or skip when they come in contact with a hard surface. To achieve the impact angles necessary for cratering, the aircraft must deliver the bombs from a high altitude level release (greater than 5000 feet) or from a diving release. Both tactics result in higher DEI but, because of the altitude needed for delivery, the aircraft have lower survivability due to increased exposure to the threats.

Weapon improvements, like the I2000 (modified Mk-84), reduce the chances for skip or weapon breakup with an improved nose cone design (1). This improvement increases survivability by allowing for low altitude delivery tactics. Although general purpose weapons provide moderate effectiveness, munitions designed specifically for penetrating concrete surfaces are a better alternative for closing the runway.

Runway Attack. In this study, there are two weapons which are designed specifically for runway closure: the Durandal and the standoff weapon. Both munitions emphasize improvements in runway damage mechanisms, but the standoff weapon also reduces aircraft exposure in the threat envelopes.

Durandal. This munition was designed for runway cratering through a joint research and development effort by the West German and French governments (28:604). It is similar in size and weight to the Mk-82 and is currently in service by several European countries as well as the U.S. The major improvement of this weapon is its ability to penetrate concrete surfaces prior to detonation regardless of the angle, altitude, or speed at delivery.

There are four main parts to the Durandal: warhead, sequencer, booster, and parachute. The sequencer is the initiator of the other main parts of the weapon and takes control at the time the Durandal is released. The sequencer deploys the parachute after release from the aircraft to retard the weapon's speed and increase its impact angle. After jettison of the parachute, the warhead is armed and the booster is ignited. The booster enables the weapon to acquire enough kinetic energy to penetrate below the surface of the concrete where a delayed detonation occurs.

Because the explosion takes place in a very compact area below the runway surface, the damage is in the form of debris upheaval, cratering, and cracking (see Figure 4). For normal crater damage (as in the general purpose weapons), the dirt and rubble is simply dumped back into the hole and a surface of quick drying concrete is poured on top. The upheaval and cracking caused by the Durandal requires heavy equipment to remove the cracked concrete prior to repairing the damage. This activity generally results in longer repair and runway closure times.

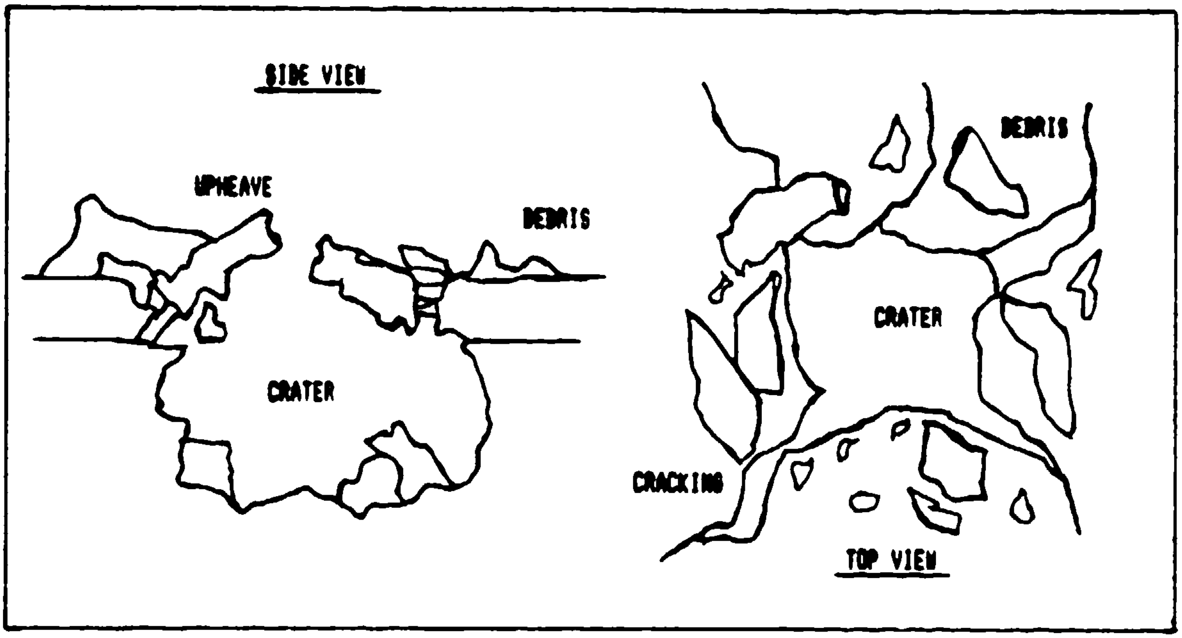


Figure 4. Runway Damage

Standoff Weapon. The standoff weapon considered in this study is a weapon based on a development effort conducted at the Air Force Armament Laboratory (AFATL) (29). Current munitions, require the aircraft to fly through the enemy target area defenses and, in most cases, directly over the target during weapons delivery. Improvements in munition technology have increased the effectiveness of certain munitions in use against runways; but. the tactics necessary for delivery have not significantly changed. Aircraft employing the new weapons have less attrition only because the new weapons reduce the number of sorties required for runway closure. In order to achieve a significant improvement in OCA missions success, a combination of improved weapons and more survivable delivery tactics is necessary.

Brunswick Defense, under contract to AFATL, designed a standoff weapon that could be released at low level and long distances from the target. The standoff tactic (releasing weapons at long distances from the target), however, is not new. General purpose bombs are currently delivered at distances up to five miles from the target by incorporating a climbing maneuver. The difference in the standoff weapon is that it represents a munition designed to fit a selected tactic instead of a modification of tactics to deliver existing weapons i.e. the climbing maneuver for the delivery of general purpose weapons.

Using the standoff weapon, the aircraft is no longer required to fly directly over the target, because the weapon may be released at ranges of up to twenty nautical miles from the aimpoint. This greatly reduces, and may even completely eliminate, target area attrition.

The standoff weapon is designed as a free-flying dispenser filled with submunitions specifically designed to close runways. The submunitions within the standoff weapon are modeled as Boosted Kinetic Energy Penetrators (BKEP), currently under development by AVCO Systems Division under contract to the Air Force (3:2).

Each BKEP functions identical to a Durandal using the parachute, booster, and delayed detonation. The major difference is size and destruction capability. The size of the BKEP allows for up to 36 to be carried internally depending on the number of rocket motors placed in the aft section of the standoff weapon (see Figure 5).

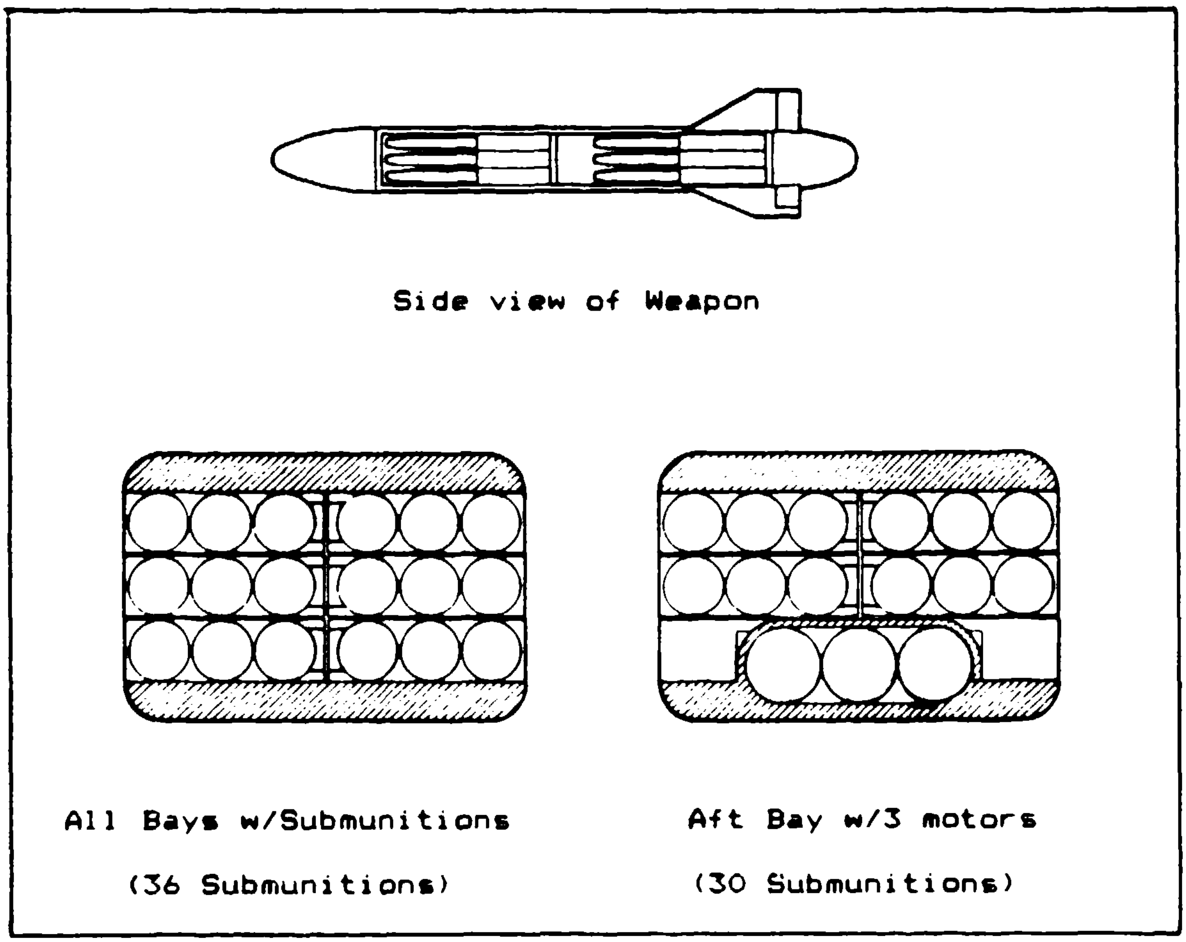


Figure 5. Submunition/Motor Configuration

The standoff weapon weighs approximately 2300 pounds and the Durandal weighs 450 pounds. Each BKEP has the capability of creating a twenty foot crater, while the Durandal produces a forty-five foot crater. Although the damage produced by each BKEP is less, the pattern of BKEPs (dispensed from the standoff weapon) is an effective method for cutting the runway. The pattern can be generated to cover a circular, elliptical, or rectangular area.

For this study, pattern generation will be limited to rectangular due to the release requirements of the other two patterns. Both circular and elliptical patterns require the delivery aircraft to overfly the target which defeats the survivability advantage incorporated into the munition's design. A sample of the variety of rectangular patterns that can be dispensed is depicted in Figure 6. The dimensions of the pattern are controlled by internal ejection mechanisms at the time of dispense.

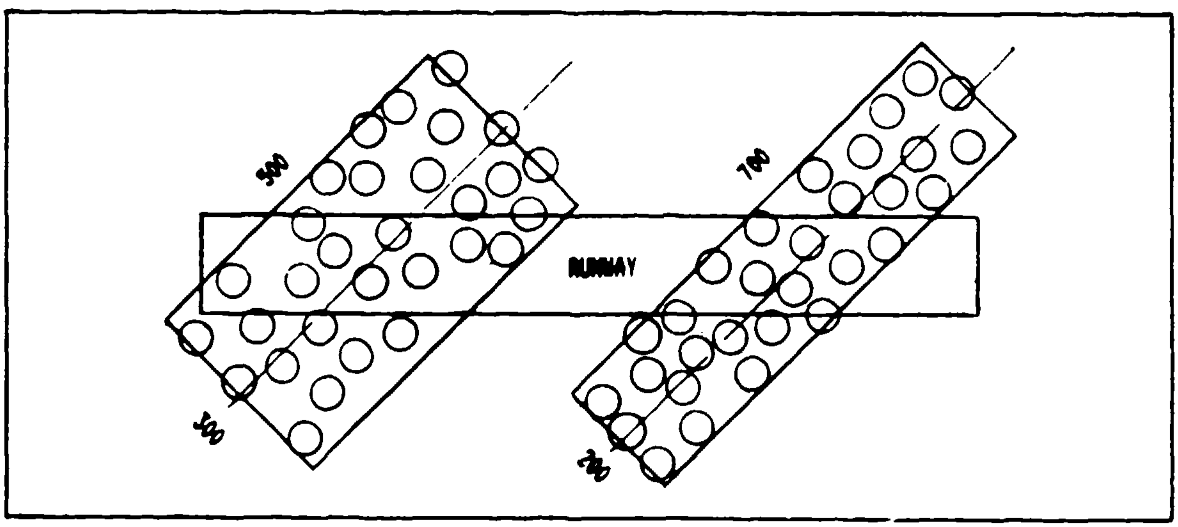


Figure 6. Pattern Generation

Tactics. Modeled in this study are the four weapon delivery tactics described in Section I. The tactics fall under two basic options: overflight and standoff.

Overflight. This option involves the deepest penetration into the terminal area defenses and, therefore, has a higher associated attrition. Although attrition is high, this maneuver is often employed because of increased weapon delivery accuracy. The two delivery tactics associated with the overflight option are level and low angle low drag (LALD).

Level. A low altitude level release, as depicted in Figure 7, is designed to reduce radar acquisition by SAM and AAA sites. The delivery aircraft flies at an altitude of about two hundred feet (or less) until point A where a climb is executed to attain the minimum weapon release altitude (point B). This release altitude is necessary for the weapons to arm and acquire a proper impact angle. The climb is also necessary to allow the aircraft a safe escape from the weapon fragmentation following detonation (14:18).

In this maneuver, the aircraft arrives at the track point (point C) at least five seconds before release of the first weapon. The time between the track point and weapons release (point D) is necessary to stabilize the aircraft at the correct release parameters to achieve the desired DE on target. After release of the last weapon (point E), the aircraft returns to low level and exits the area.

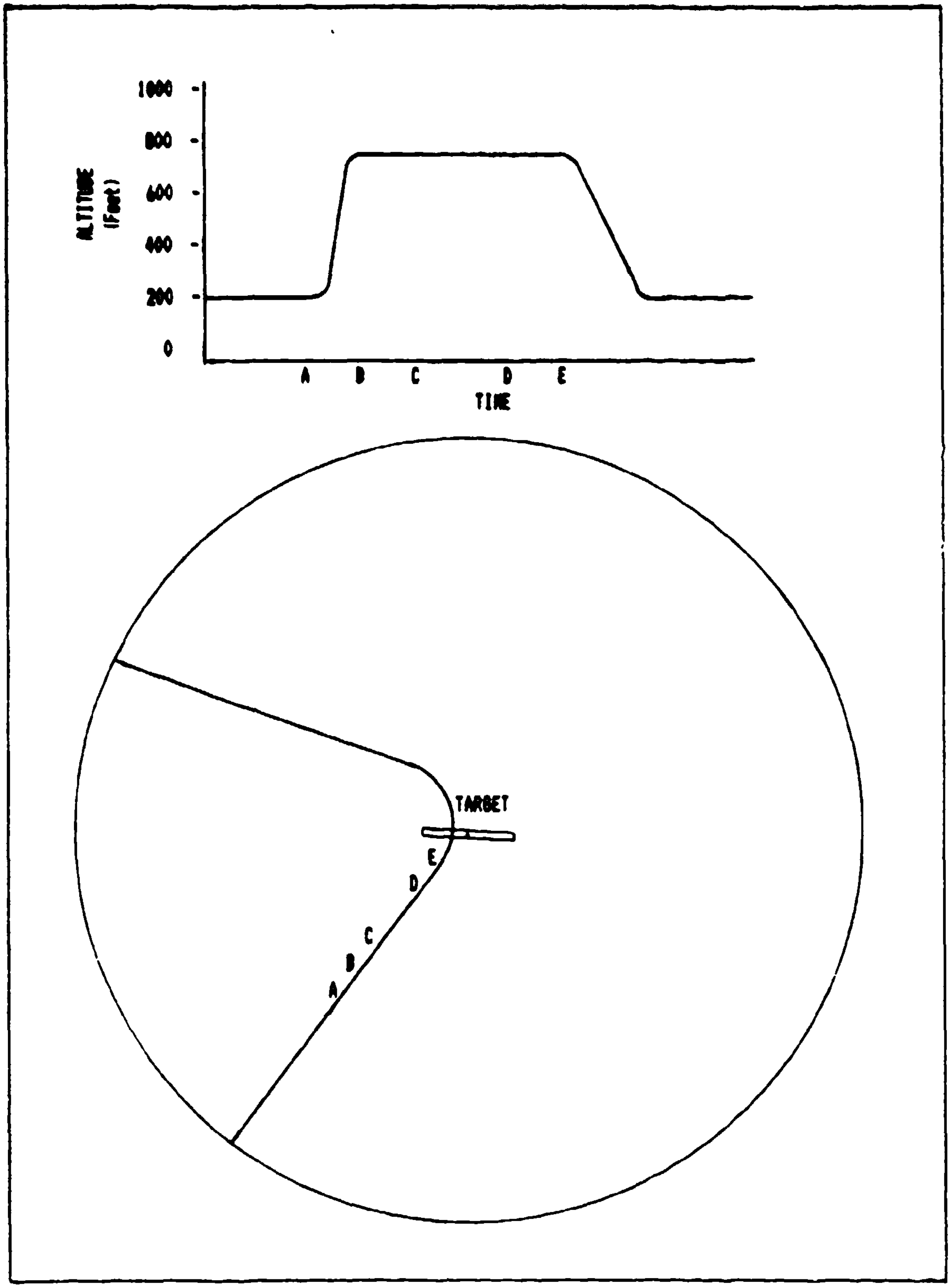


Figure 7. Level Delivery Tactic

LALD. The LALD maneuver modeled in this study is shown in Figure 8. This delivery is more accurate than the level delivery due to the improved target acquisition from a higher altitude, but exposure to SAM and AAA threats is increased.

To minimize the increased exposure the aircraft approaches the target at an altitude of 200 feet (or less) and executes a pop-to-LALD maneuver. The maneuver begins at point A where the aircraft initiates a 30 degree turn. The aircraft rolls out at point B and begins a 20 degree climb using a 3 to 5 G pull to quickly attain the desired pitch attitude. The target is visually identified during this climb so that, at the roll-in point (point C), the aircraft can be maneuvered to roll-out at the track point (point D) aimed at the target.

As in the level release, the time between the track point and release point (point E) is used to achieve proper release conditions. The dive angle is maintained until the last weapon is released (point F) and the aircraft initiates an egress maneuver and descends to 200 feet to exit the target area.

Standoff. This term is associated with both an option for delivering munitions and as the name for the new weapon being modeled in this study. This option is employed to deliver general purpose weapons by using a toss maneuver and to deliver standoff weapons using a simple low level weapon release maneuver.

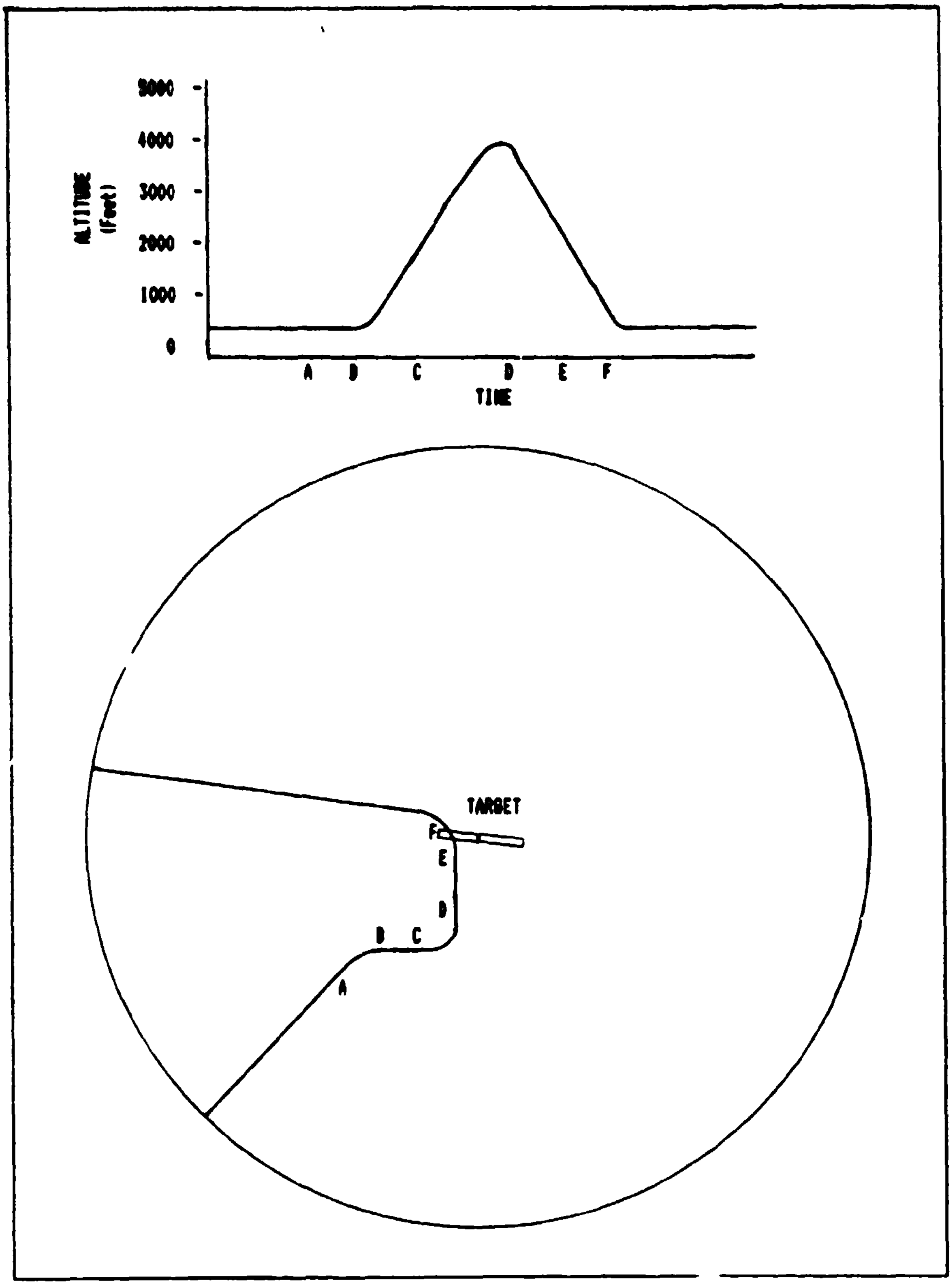


Figure 8. Low Angle Low Drag (LALD) Delivery Tactic

Toss. Figure 9 depicts the toss maneuver modeled in this study. The aircraft approaches the target at about a 200 foot altitude until point A where it begins a 3 to 5 G pull to establish a 45 degree climb. Because of the long distance from the target (approximately four miles), the aircraft must achieve a relatively high altitude (over 4000 feet) at release (point B). The climb is maintained through release of the last weapon (point C) where a diving, turning egress maneuver is initiated.

In the toss maneuver, the advantage of standoff (no overflight of the target) is lost with the need to achieve a high delivery altitude. This high altitude increases exposure and vulnerability to terminal defenses.

Standoff Weapon Delivery. Employment of the standoff weapon provides the aircraft increased survivability over the other three delivery tactics, because the aircraft can reduce or avoid any time in the terminal threats. If the aircraft enters a terminal threat, it is not required to enter the higher, more lethal portions of the envelope during delivery because the standoff weapon is designed to be released at low altitudes.

Figure 10 shows the standoff weapon release tactic that will be considered in this study. The aircraft maintains a low altitude of 200 feet throughout the entire maneuver. Weapon release points (point A to point B) are chosen at a distance from the target to reduce penetration into terminal defenses.

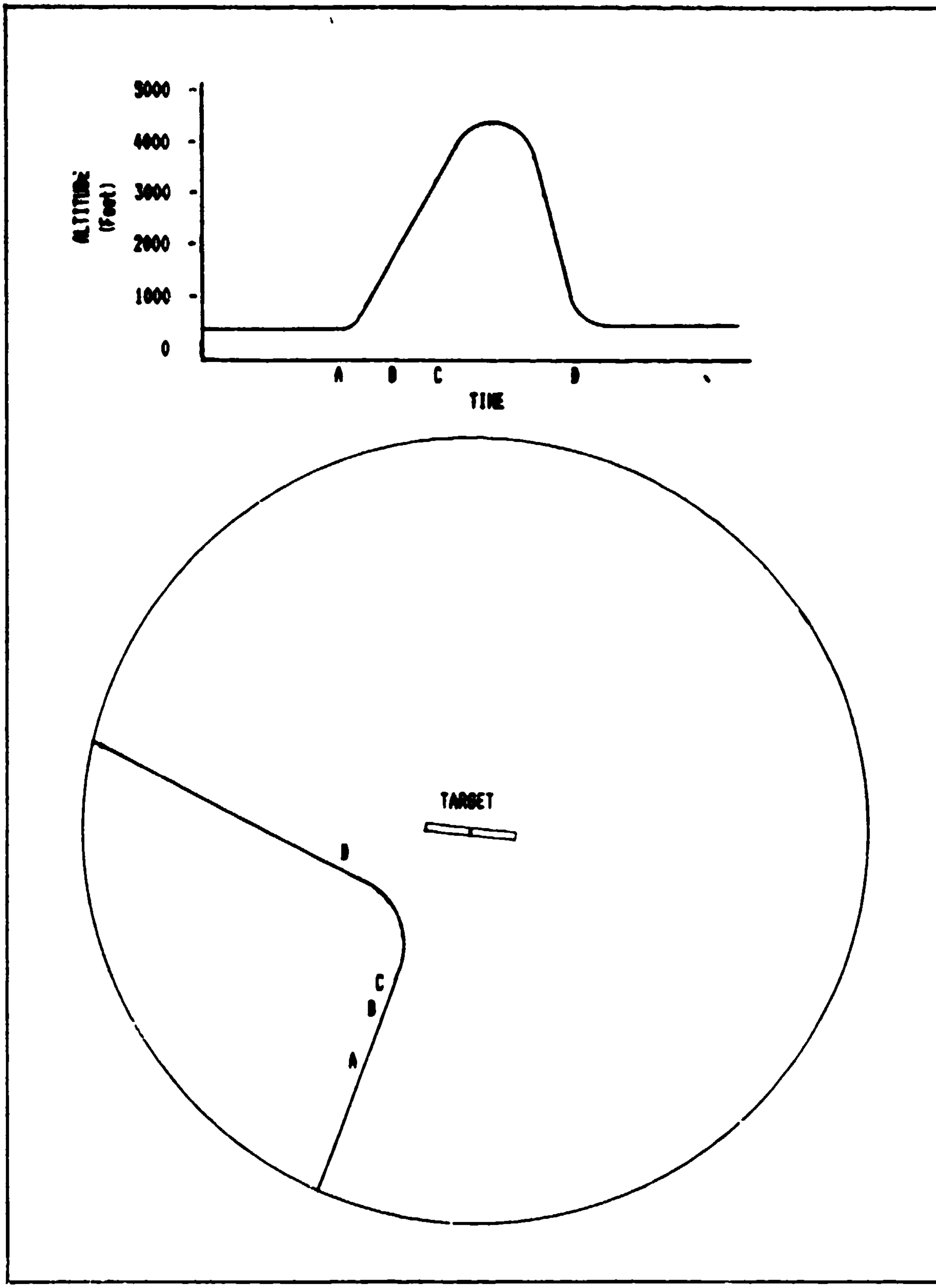


Figure 9. Toss Delivery Tactic

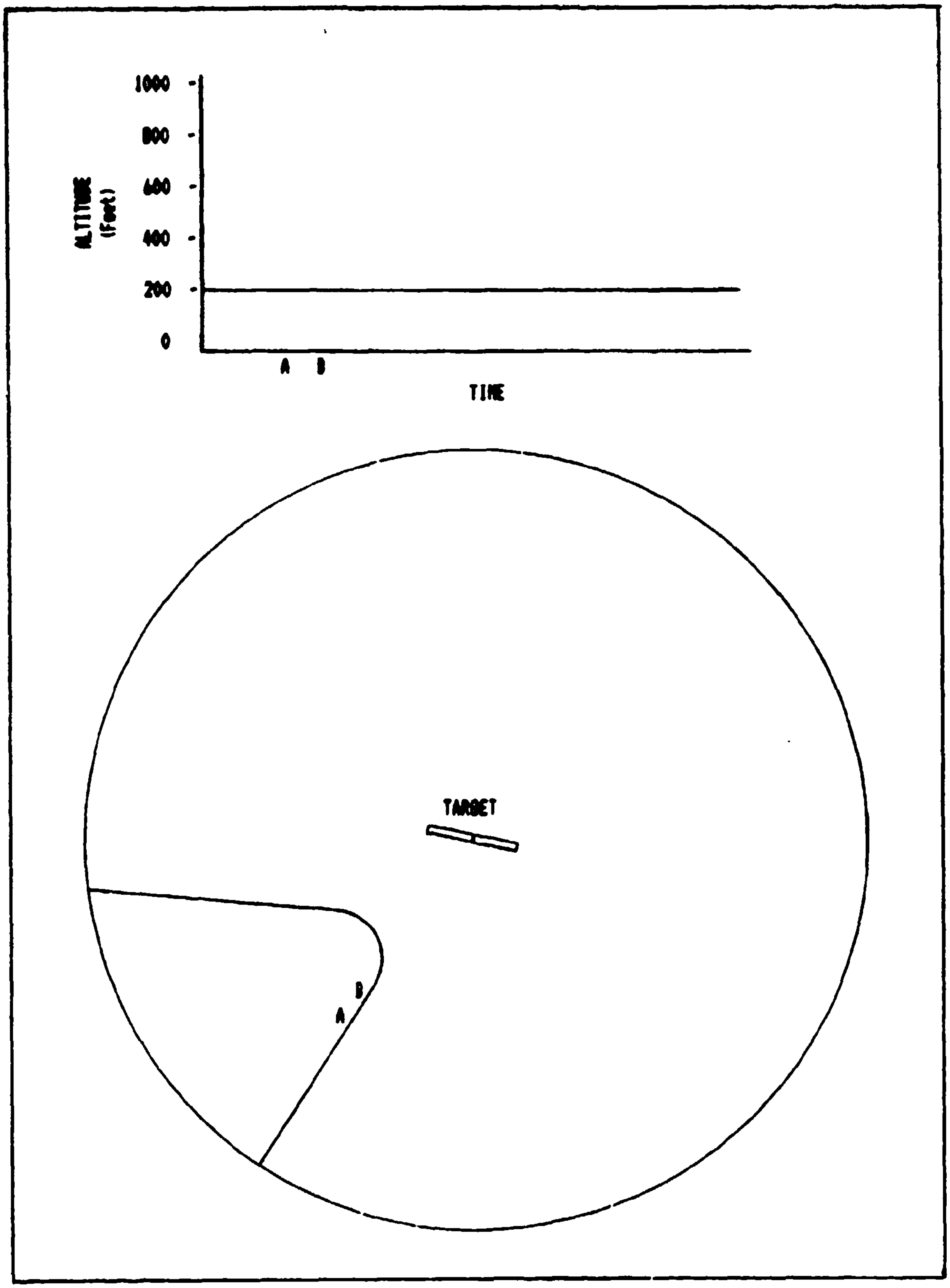


Figure 10. Standoff Weapon Delivery Tactic

Enemy Forces

The enemy forces consist of a Warsaw Pact airfield and the surface-to-air defenses located around the airfield, as depicted in Figure 11. The coordinate system used for description of the target area, defense system locations, and weapon delivery aimpoints is referenced to the center of the main runway. Although there are many potential targets associated with an airfield, e.g. fuel depot, maintenance building, and weapon storage area, the main runway is the target in this study.

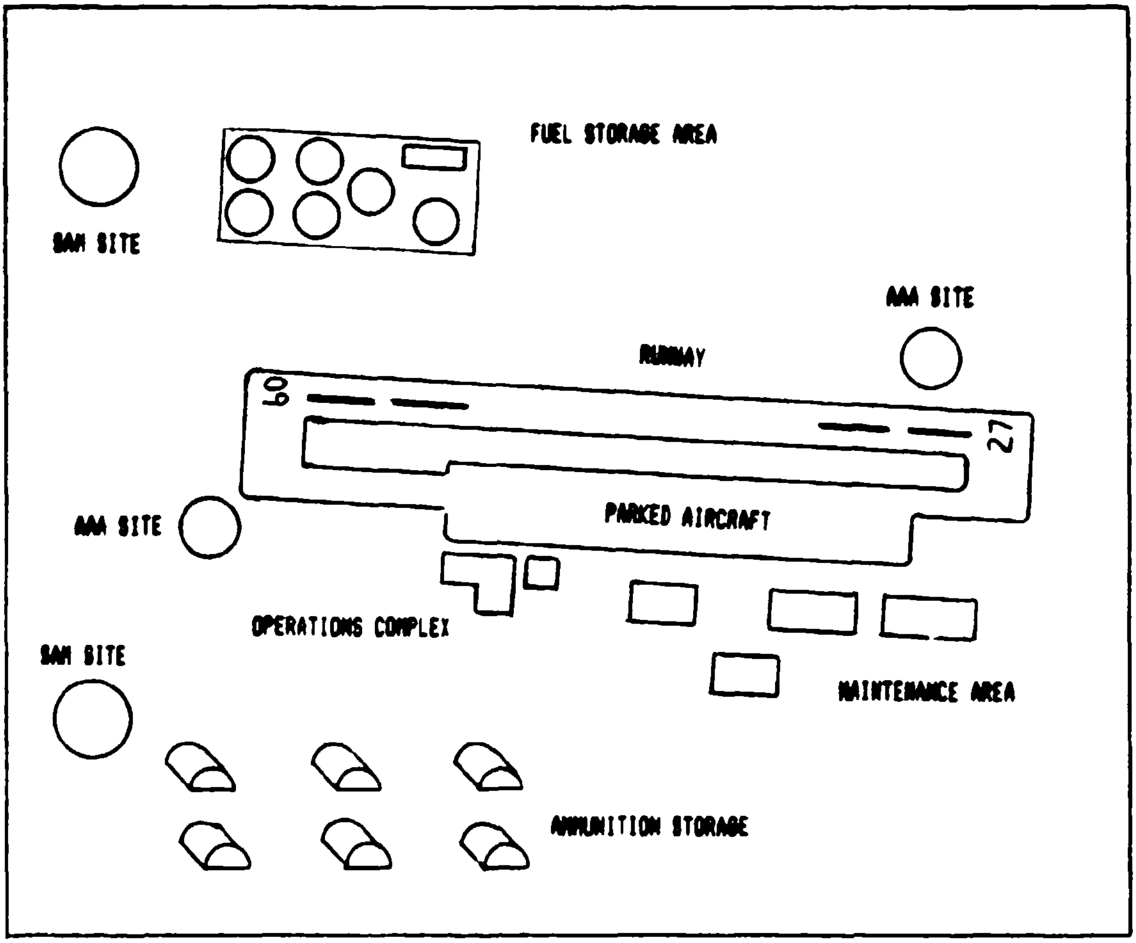


Figure 11. Airfield and Site Defenses

Target. The airfield runway is shown in Figure 12 and is based on an analysis of thirty-six East German airfields (6:6). The runway lies five degrees off the East-West line. The surface is constructed of 40 foot square slabs of reinforced concrete. The use of slabs confine the effects of upheaval and cracking within the square area when runway munitions detonate (5).

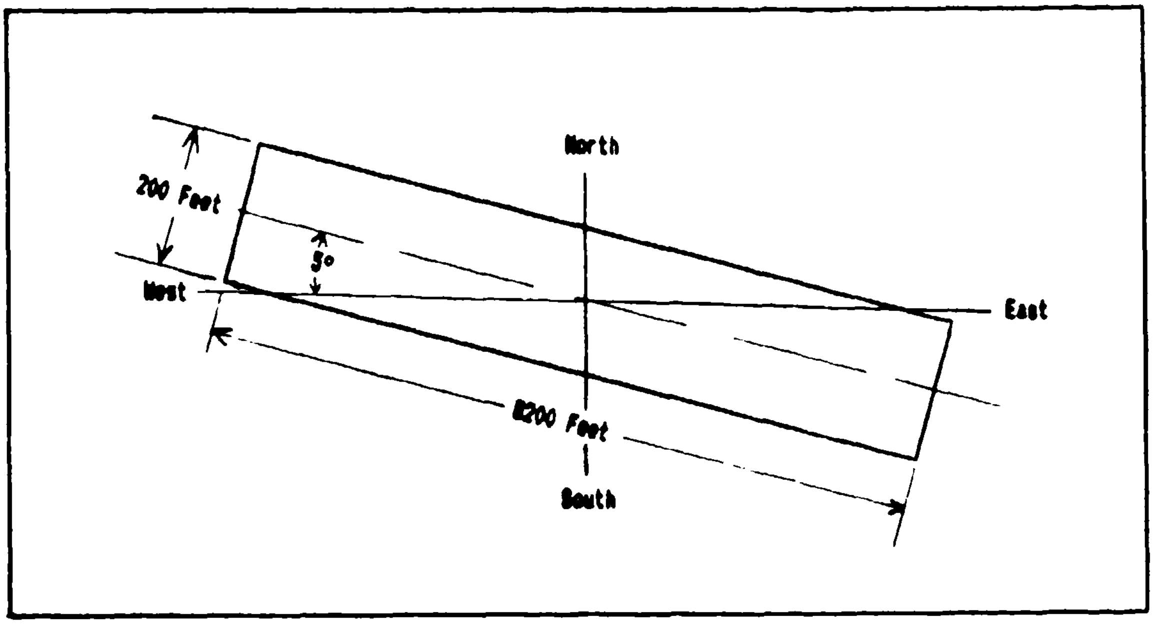


Figure 12. Enemy Runway

The steel rods used to reinforce the concrete are necessary to support the weight of aircraft utilizing the airfield, but hamper runway repair. When runway munitions penetrate the surface and detonate, they cause upheaval of large blocks of debris forcing some of the rods to bend upward. The bent steel rods eliminate the chance for simple repair action of filling the hole and covering it with quick-drying cement. Instead, either the rods must be cut or the entire damaged block must be removed by crane before repairs can begin. Both actions require extensive additional repair time.

Defenses. The surface-to-air forces modeled in this study are limited to the fixed systems that defend the runway and consist of two SAM and two AAA sites. Although mobile systems may be deployed around the airfield, it is not possible to predict the type or number of systems. The threat locations for each site, Figure 11, were determined after review of the East German Airfield report (6:6) and interviews with Foreign Technology Division (FTD) experts (16). The capabilities of the defenses, Table III, are based on correspondence from AFATL Survivability Branch personnel (8:2) and the FTD interviews (16).

Table III

Enemy Defense Capabilities

	SAM 1 (current)	SAM 2 (out-year)	AAA
Minimum Altitude (feet)	200	60	0
Minimum Range (feet)	10000	8000	600
Maximum Range (feet)	81000	108000	9800
Confounding Delay (sec)	25-35	25-35	30
Engagement Window (sec)	17	17	1
System Reliability	.735	.81	1.0
Simultaneous Engagements	1	4	1
Max Firings before Reload	12	24	6

AAA. Each site is composed of a single unit which has four 23mm cannons (24:120). The cannons are radar controlled and can fire six one second bursts separated by one second of cooling. The use of ECM against the AAA is not modeled because the AAA's threat envelope (max range of 9807 feet) is within the radar burnthrough range. The burnthrough range is the distance from the AAA radar to the aircraft where ECM becomes ineffective. Also, there is a minimum engagement range (dead zone) of 600 feet due to the cannon's inability to elevate completely. Due to the confounding delay (target selection and re-acquisition), the AAA systems can only engage one target per attack.

SAM. The SAM threats, whose locations are also shown in Figure 12, consist of one current and one out-year system. The current system is representative of the SAM sites now in operation at airfields throughout the Warsaw Pact and have been in place since 1961 (24:97). The out-year system represents recent technological developments projected to be in operation around Eastern European airfields about the same time as a standoff weapon would be expected to enter the inventory (24:101). Both systems are affected by ECM and are not modeled with any ECCM capability. The engagement envelope of each system is defined with respect to the target's altitude and range from the respective SAM system.

The current system can detect targets at altitudes above 200 feet and ranges up to 81,000 feet. The dead zone is an area within a radius of 10,000 feet around the fixed site. A target must be in the threat envelope for five uninterrupted seconds before it can be fired upon. When a launch is ordered, the missile and fire control systems have an overall reliability of .735. This system can fire up to 12 missiles before reloading and is limited to engaging one target at a time.

The out-year system is a great improvement over the current airfield defenses because it can engage up to four targets simultaneously and has improved launch and detection capabilities. Targets flying at altitudes above 60 feet and within a range of 108,000 feet may be fired upon. The minimum acquisition time remains 5 seconds but the dead zone is an area with a radius of only 8000 feet. The missile launch reliability is .81 and 24 missiles are available for firing before reload is required.

Uncontrollable Forces

The uncontrollable forces can be a significant factor in any system and must be considered if they influence the outcome. In this study, terrain and weather are such forces.

Terrain. The terrain of Central Europe is a combination of rolling hills and dense forests. These two elements are positive factors in favor of the ingressing aircraft by allowing for terrain masking against airfield defenses. The effects of masking are modeled in all the defenses with variations in the maximum detection and engagement ranges. These ranges are increased or decreased by up to ten percent each time a target (aircraft or standoff weapon) is evaluated for time in the defense system's envelope. This allows for a target to enter the engagement range, be detected, and then be hidden from the system's radar due to terrain masking.

Weather. The weather can be an important factor in flying operations if good visibility is a tactical requirement; because, a common weather condition in Central Europe is low visibility with low cloud ceilings. In this study, the OCA tactical operations, except for the LALD tactic, are accomplished using radar systems for aiming the weapons. Therefore, the affects of weather are diminished.

The exception of the LALD tactic, described under friendly force tactics, is due to a requirement for the pilot to visually sight the target before rolling out on final. The level tactic is generally planned for either visual or radar aiming and the standoff options must always use radar for weapons delivery. Therefore, if visual acquisition of the target is impossible due to weather conditions, then the LALD tactic cannot be used in the OCA mission area.

Attack Scenario

The modeled OCA mission consists of a two-ship element attacking from the West with general purpose weapons, runway attack munitions, or standoff weapons. For this study, aircraft attrition during the ingress and egress phases is ignored. The target phase of the mission begins when the aircraft fly within twenty nautical miles of the center of the runway, as shown in Figure 13.

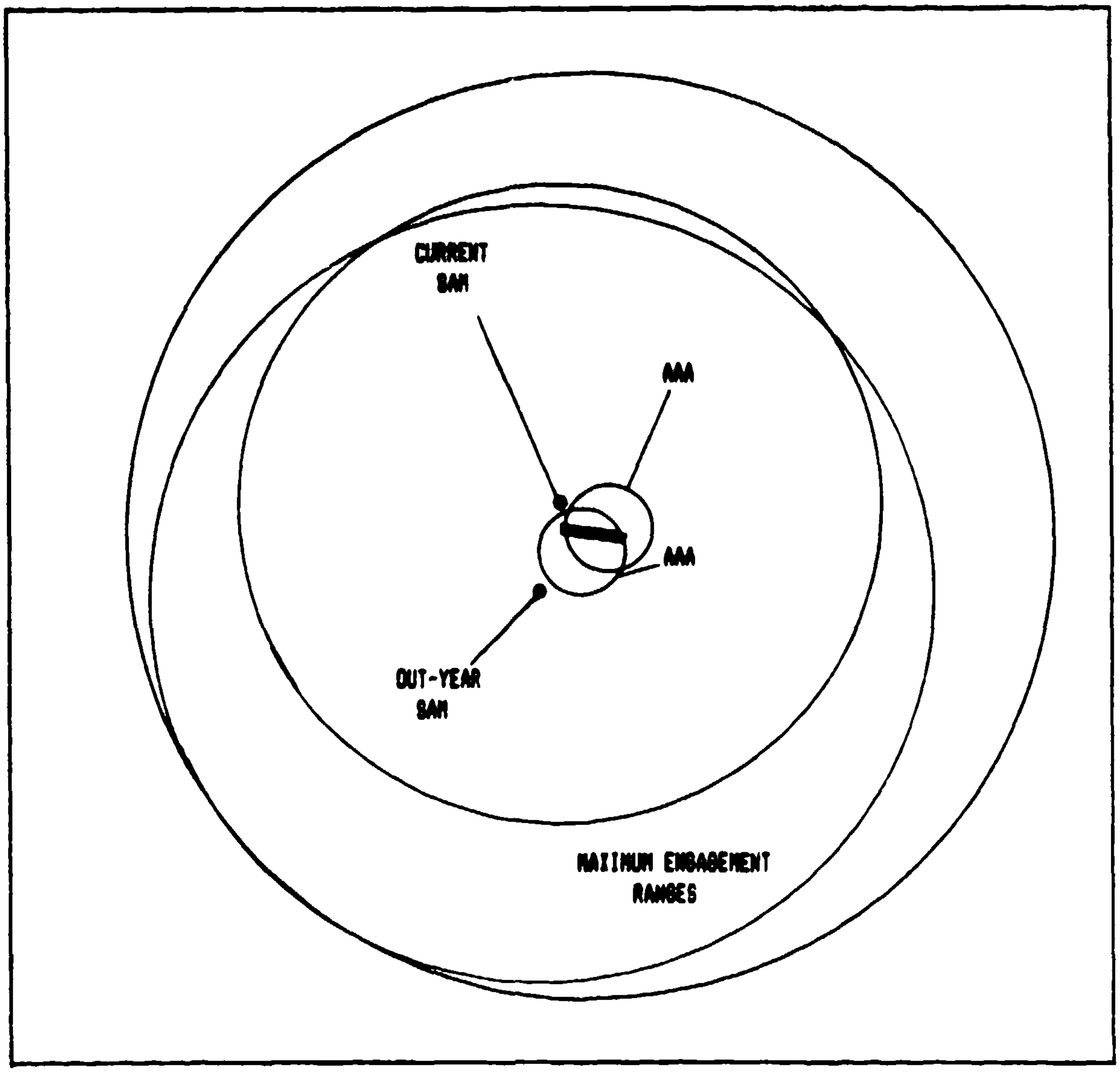


Figure 13. 20 NM Mission Area

The aircraft enter the terminal area at headings between 030 and 150 degrees and are detected and engaged by the target area defenses as the aircraft perform their maneuvers. With the standoff tactic, the defensive systems will also engage the weapons after they are released from the aircraft. Although certain parts of the attack scenario vary, depending on whether the aircraft are carrying current inventory munitions or standoff weapons, the basic mission objective is to close the enemy runway.

Runway closure occurs when delivered munitions cause enough damage (cratering, upheaval, and cracking) to deny a minimum clear area (MCA) for flight operations. The MCA is defined, for this study, as any 3000 x 50 foot undamaged surface. For conventional tactics, all weapons are released in a single string centered on the appropriate aimpoint. All standoff weapons carried by an aircraft are targeted against the same aimpoint. Figure 14 shows the runway aimpoints and attack angle.

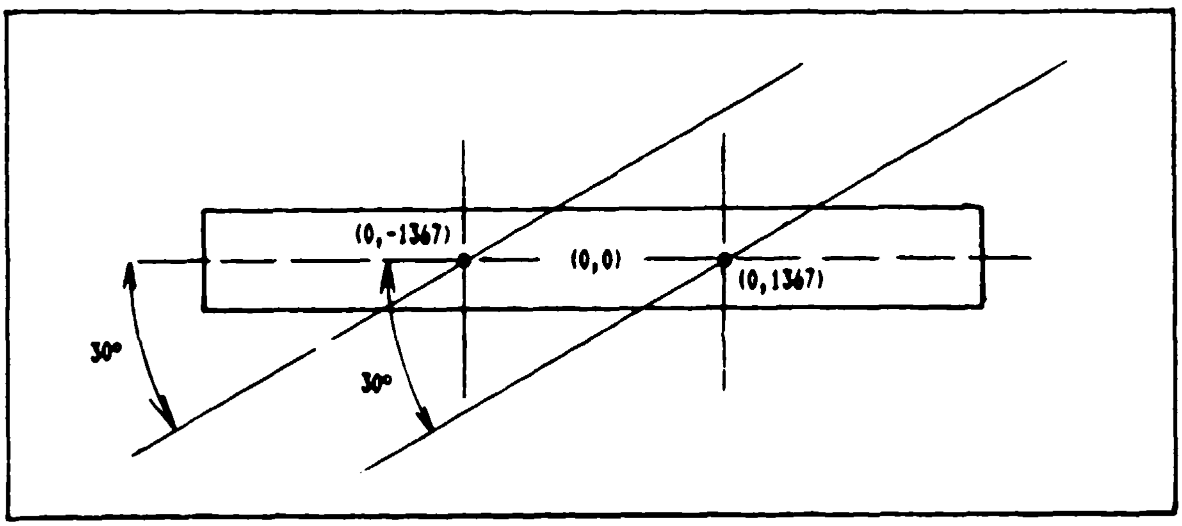


Figure 14. Runway Aimpoints and Attack Angle

Because the runway is 8200 feet in length, only two aimpoints are necessary to divide the runway length into sections less than the minimum required length (3000 feet). The minimum clear width (50 feet) is denied by delivering the string of munitions on a line at a desired attack angle that crosses the runway. This is done by releasing weapons or submunitions a fraction of a second apart using an intervalometer.

For this study, the mission is planned with two aimpoints and a 30 degree attack angle to provide a high probability of closure when delivering current inventory munitions. The 30 degree attack angle was chosen because it is commonly accepted in tactical operations as the optimum angle. Since the standoff weapon is only a projected capability, an optimum attack angle has not been determined, but the principle behind two aimpoints for runway closure is the same.

While the aircraft are maneuvering to release points and then egressing and the standoff weapons are maneuvering to dispense points, they will interact with terminal defenses. The probabilities of engagement and kill (system interactions) for each defensive system are determined by the range, altitude, time in threat, ECM capabilities, and physical characteristics of the target.

When a target enters a threat system's envelope and is fired upon, the missile sites launch a salvo of two missiles, both proximity fused. Once the missiles are fired, the SAM site acquires a new target, if one exists, and may fire another salvo after expiration of the confounding delay. The targets in the site's range are vulnerable to attack until they leave the envelope or the SAM site requires reload.

The two AAA systems are modeled identically. Each site may fire a burst of projectiles from its four cannons each second separated by one second of cooling. The burst must have contact in order to destroy an aircraft or weapon and a site can only engage one target per attack. Each AAA attack will terminate when either the target is destroyed, the site requires reload, or all potential targets have exited the site's range.

The attack scenario ends when the last aircraft or standoff weapon is destroyed or completes its mission. The aircraft mission is complete when it departs the 20 NM ring and the standoff weapon is finished when it reaches the dispense point. When the scenario is complete, the number of friendly forces destroyed and the damage effectiveness of munitions on the runway are assessed to determine the measurement of the interactions.

MOE of Interactions

In creating a methodology for comparing different munitions, it is necessary to measure the effectiveness of the interactions between different elements within the model. The elements in this model are the: friendly forces (aircraft and standoff weapons), defensive systems, munitions, and runway. The MOE between the defensive systems and the friendly forces is attrition. The MOE between the munitions and the runway is runway closure probability.

Attrition. This study evaluates attrition of friendly forces within a 20 NM ring around the enemy airfield. Previous efforts have studied attrition, but only with respect to aircraft. Attrition of standoff weapons released at large standoff distances from the runway was ignored in these studies. It is unclear whether the Warsaw Pact would attempt to engage such a weapon; but, if a standoff weapon which presented a threat to the airfield were employed, it is assumed that equipment would be dedicated and a policy adopted to defend against such a threat. Friendly force attrition can occur due to either the SAM missiles or the AAA which defend the airfields.

SAM. The capabilities of the two missile systems represented in the model are estimates of current and future systems in the Warsaw Pact. The probabilities associated with each system are:

Pl = Probability of launch each second
Pr = Reliability of missile and fire control system
Pk = Probability of missile destroying target

The probabilities for interaction with an aircraft were supplied by AFATL Survivability Branch personnel (8:5-17). The adjustments to the probabilities made for engagement of a standoff weapon were based on interviews with AFATL and FTD analysts (9; 16). These adjustments are reductions in defensive system effectiveness because of the different physical characteristics of the standoff weapon e.g. smaller size, reduced radar cross section, and cooler engine exhaust. The Pl is determined after a target has been in the threat's envelope for a minimum of five consecutive seconds (no interruption by terrain masking). The computation of Pl is made every second based on the engagement window and average launch probability during the window. The window for both threats is 17 seconds and the average launch probabilities during the window (Pl^) are .20 and .30 for Threat 1 and Threat 2, respectively (16).

The equation used for computing Pl for each threat is:

$$Pl = 1 - Pnl ,$$

where Pnl = Prob (no launch each second)

Deriving the no launch probability per second comes from the probability of no launch during the window (Pnl^) and the assumption that each launch decision during the window is an independent event. Therefore, the Pl is computed from:

$$Pnl\hat{} = Pnl^{17} = 1 - Pl\hat{}$$

Solving for Pnl,

$$Pnl = \sqrt[17]{1 - Pl\hat{}}$$

Therefore,

$$Pl = 1 - Pnl$$

Table IV shows the launch probabilities during the window for the aircraft and the standoff weapon based on interviews with FTD personnel (16).

Table IV

SAM Launch Probabilities (Pl^)

Target	Threat 1	Threat 2
Aircraft	0.30	0.20
Standoff Weapon	0.10	0.05

If a target is detected and the system initiates a launch, the reliability of the system, Pr, is used to determine a successful firing. Because a launch consists of a salvo of two missiles, the determination is made independently for each missile. After firing a missile, the Pk is computed for each successfully launched missile. The computation is based on the target's range, direction (to or from the threat site), altitude, ECM status, and radius of closest approach at the time of missile launch. A matrix, similar to Figure 15, determines the correct Pk code for fighter size aircraft engagements with the SAM sites. There are four matrices for each threat that represent kill probabilities based on the aircraft's altitude and ECM status (see Table V).

Table V

Altitude and ECM Grid Breakdown

Below 1000 feet	No ECM
Below 1000 feet	ECM
Above 1000 feet	No ECM
Above 1000 feet	ECM

FLIGHT

RANGE					
	-81000	0	0	0	0	0
	-72000	0	0	0	0	0
	-63000	0	0	0	0	0
	-54000	0	0	0	0	0
	-45000	3	0	0	0	0
	-36000	3	4	3	0	0
	-27000	2	3	3	3	1
	-18000	1	2	2	3	2
	-9000	0	1	2	3	2
	THREAT	0	1	2	3	2
	9000	0	2	3	3	1
	18000	3	4	5	2	0
	27000	7	7	6	1	0
	36000	5	5	5	0	0
	45000	2	2	2	0	0
	54000	0	0	0	0	0
	63000	0	0	0	0	0
	72000	0	0	0	0	0
	81000	0	0	0	0	0
		8700	17400	26100	34800	43500
		RADIUS OF CLOSEST APPROACH (RCA)				

Figure 15. Sample Engagement Grid

The Pk code in the matrix represents a probability interval between 0.0 and 1.0, see Appendix E. The intervals are 0.1 in length and are centered on one tenth the value of the code number (e.g. Code 2 yields the range .15 to .25). To model the reduced vulnerability and increased difficulty in engaging a smaller target, the probability for the standoff weapon is selected from the aircraft engagement matrices and reduced by 75 percent.

AAA. Because both AAA sites represent the same system, the computation of interaction probabilities is identical for each site. The factors influencing interaction are: target range, altitude, turn status, and time in threat. As stated earlier, the effects of ECM are not considered because the site's threat envelope is defined within the AAA's radar burnthrough range.

Unlike the SAM threats, the attrition value for the AAA is determined with only the Pk of the system. After a target has been selected for engagement by the AAA site, the probability of firing a burst each second is 1.0. The firing reliability (Pr) is also assumed to be 1.0 until the ammunition is depleted or the target is destroyed (16). The Pk is based on the range, altitude, and turn status of the target. Figure 16 shows the range and altitude graphs used to determine the Pk for the AAA. The combined Pk is the product of the range and altitude probabilities.

The turn status effects are modeled as a reduction in the Pk because of the increased difficulty in tracking a maneuvering target. Finally, if the target is a standoff weapon the Pk is further reduced because the kill probability graphs are based on a fighter size aircraft.

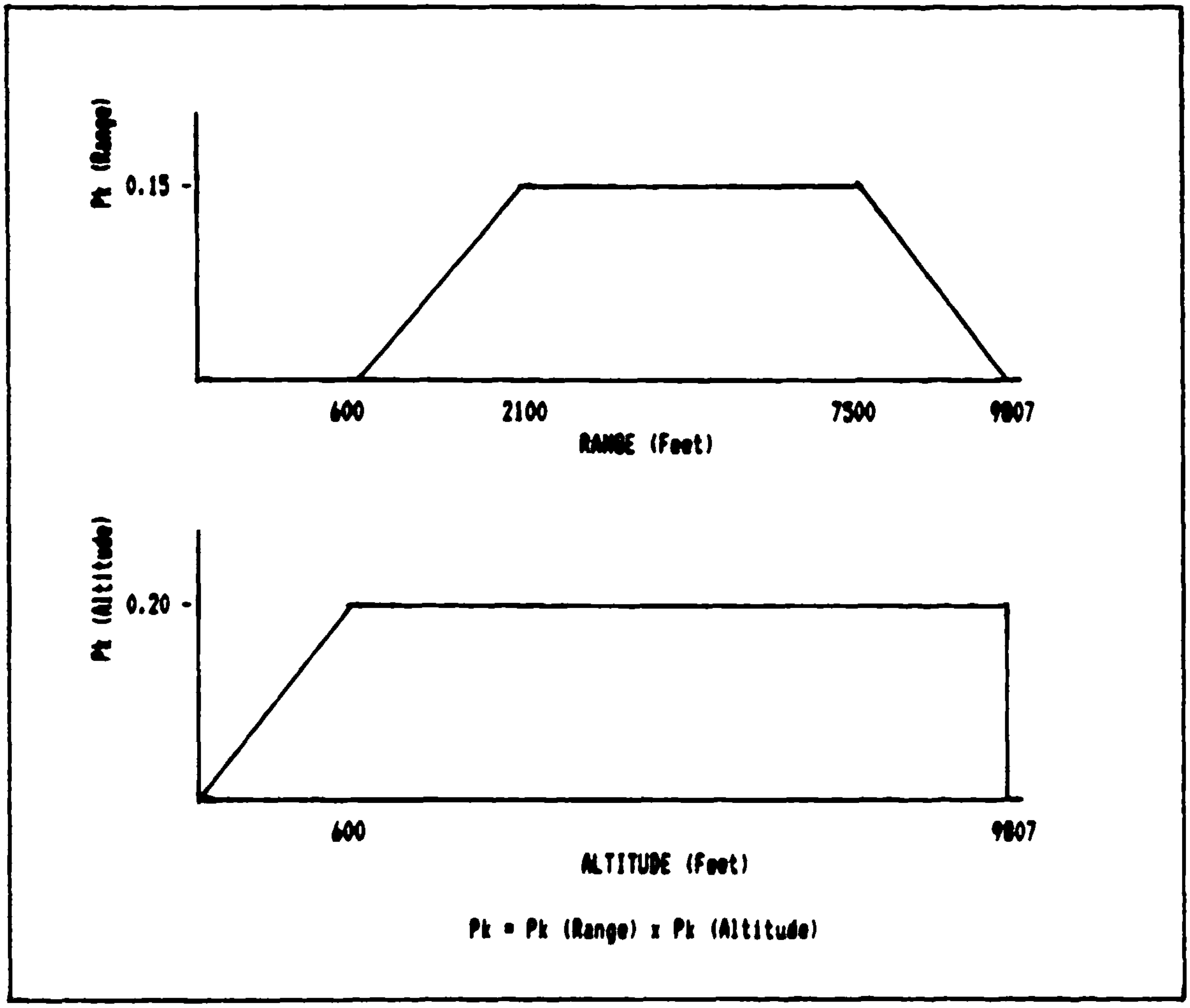


Figure 16. AAA Kill Probability Graphs

<u>Closure Probability</u>. The capabilities of current inventory munitions on the runway employing a selected conventional tactic (level, LALD, or toss) is classified. The values are available in the Joint Munitions Effectiveness Manuals (JMEM), but will not be used in this study. The effectiveness of the standoff weapon is not a

known value because it is only a projected capability; therefore, the values must be determined.

<u>Current Munitions</u>. To remain unclassified in the study, closure probability estimates for current weapons have not been used. To demonstrate the capability of selecting the proper values from a classified data matrix, location identifiers have replaced the weapon's capabilities. Table VI shows the values loaded in the matrix. Substitution of the classified capabilities of weapon and tactic combinations for the location identifiers will display the proper DE for comparison.

Table VI

Current Munitions Location Identifiers

Weapon	Level	LALD	Toss
Mk-82	11	12	13
Mk-84	21	22	23
I2000	31	32	33
Durandal	41	42	43

<u>Standoff Weapon</u>. As previously stated, the standoff weapon exists only as a research and development munition. Therefore, it was necessary to develop an equation to represent its damage effectiveness. To produce the equation, data was extracted from the Brunswick Defense Report on their development efforts (31) and used as an input to the Attack Assessment Program (AAP). The Brunswick report provided information on the standoff weapon and AAP provided the necessary model to convert this data to closure

probabilities. The full explanation and discussion of the steps taken to use the data and derive the equation for the weapon effects is in the following section, Section III.

III. Input Data Analysis

Creating a methodology for comparing current munitions with a future weapon (standoff weapon) required predicting attrition of the new weapon against runway defenses and its submunition's effectiveness (DE) against a hardened runway. The model, produced in this study, provides the means for predicting outcomes of attrition of the delivering aircraft and standoff weapon during their maneuvers through the target area defenses. This information was acquired in a similar manner to aircraft attrition when delivering current inventory munitions. But, the standoff weapon submunition's' effectiveness cannot be acquired in the same manner as the DE for current munitions. As stated in Section II, the DE for current munitions is found in JMEM. But, the standoff weapon's DE is an unknown and must be computed as a function of certain factors. To determine what factors were most influential in predicting DE and to compute DE values, it was necessary to find an applicable model.

Attack Assessment Program (AAP)

This Monte Carlo simulation model is widely accepted for accurately predicting DE for munitions delivered against a runway and is the source for many JMEM values for current munitions. There are different versions of AAP and the Wang version was identified, by Mr. Jerry Bass of the Air Force Armament Laboratory, as the most appropriate version for this study. This version is preset with the characteristics of the standard Warsaw Pact runway, thereby reducing inputs; and, it is flexible enough to run both unitary and dispenser weapons (5).

The AAP has several input value requirements that must be set for each simulation. For this study, many of the values are constants because of the assumed scenario and characteristics of the system elements. Those values that vary with changes in attack parameters were also identified for analysis. These values, which will be discussed, affect the delivery of a single standoff weapon at a single aimpoint.

Constants. The constant values are listed in Table VII and reflect target dimensions, closure requirements, and weapon related facts. Two hundred replications were run for each set of inputs to reduce the variance and allow the DE value to stabilize.

Table VII

AAP Input Constants

Runway Length and Width	Minimum Clear Length and Width
Aimpoint Coordinates	Number of Attacks
Number of Weapons	Reliability of Weapon
Crater Diameter	Reliability of Submunitions

1. Runway length and width were described in Section I, but for the purposes of determining the DE of a single weapon on a single aimpoint, a 5467 foot segment of the runway is input for the length.

2. Minimum clear width and length were described in Section II, and are set at 50 and 3000, respectively.

3. The aimpoint coordinates are the center of the runway segment using the x-y coordinate system.

4. The number of weapons, weapon reliability, and number of attacks are all set at one.

5. The crater diameter applicable to each submunition is set at 20 feet and the submunition reliability is .75 (1).

Variables. Table VIII lists the input parameters that were considered as factors affecting the DE of the standoff weapon.

Table VIII

AAP Input Variables

Circular Error Probable
Number of submunitions
Attack Angle
Pattern Length
Pattern Width

Circular Error Probable (CEP) is defined as the radial area which would enclose fifty percent of all the bombs aimed at the center of a circle. In this case, the definition applies to the standoff weapon by considering the center of the standoff weapon's rectangular pattern as the bomb. The submunitions are dispensed about a center which is targeted for the aimpoint. The submunitions dispense randomly about the center in a preset pattern size. Regardless of the pattern size, if one hundred standoff weapons dispensed about an aimpoint, fifty percent of the pattern centers would land within a radial distance, CEP, from that aimpoint.

The CEP is expected to be the most influential factor for determining DE. The obvious reason is accuracy. CEP has been shown to be a function of flight time and off-boresight angle (31).

Because the weapon is released at great distances from the dispense point and is not modeled with any guidance updating capability, its CEP increases with longer flight times (flyout time) and large turns (off-boresight). Both factors begin at the release point and terminate at the dispense point. Although flight time may be easily understood, off-boresight requires further explanation.

Off-boresight is a function of the aircraft's release coordinates and heading and the weapon's programmed attack angle across the runway. Figure 17 depicts a single release point situation where several different off-boresight values can be derived. The aircraft releases weapon A having an attack angle of zero degrees and weapon B which has an attack angle of 90 degrees. Weapon A makes two 85 degree turns summing to an off-boresight of 170, but weapon B only makes two 45 degree turns summing to 90. If the aircraft's release heading were changed then the off-boresight values would reflect that change.

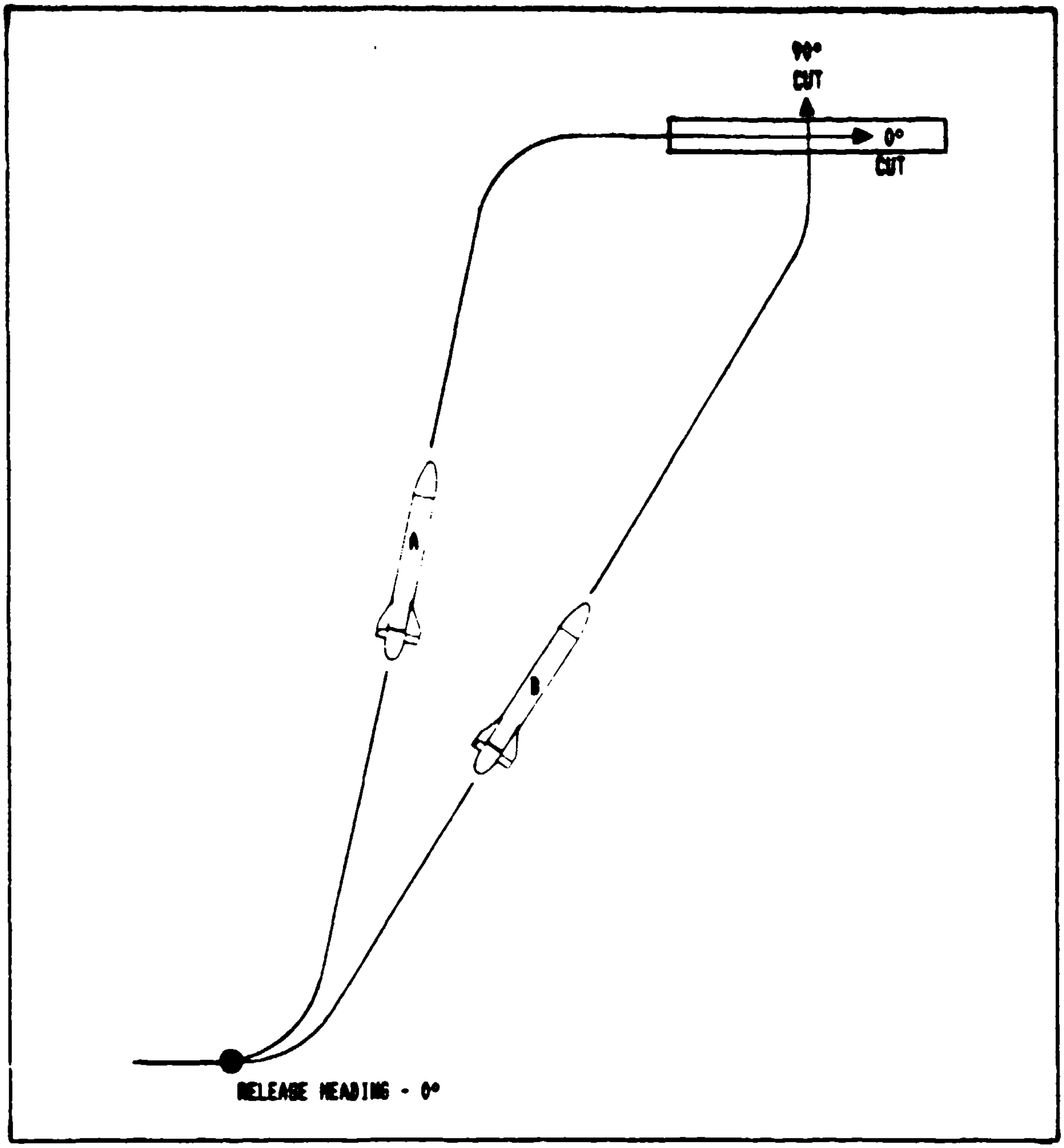


Figure 17. Off-boresight

Brunswick Defense performed simulations and analysis to predict CEP as a function of flight time and off-boresight angle, see Figure 18 (31:39). Data from this graph were used to develop a linear equation to be incorporated into the model using regression techniques.

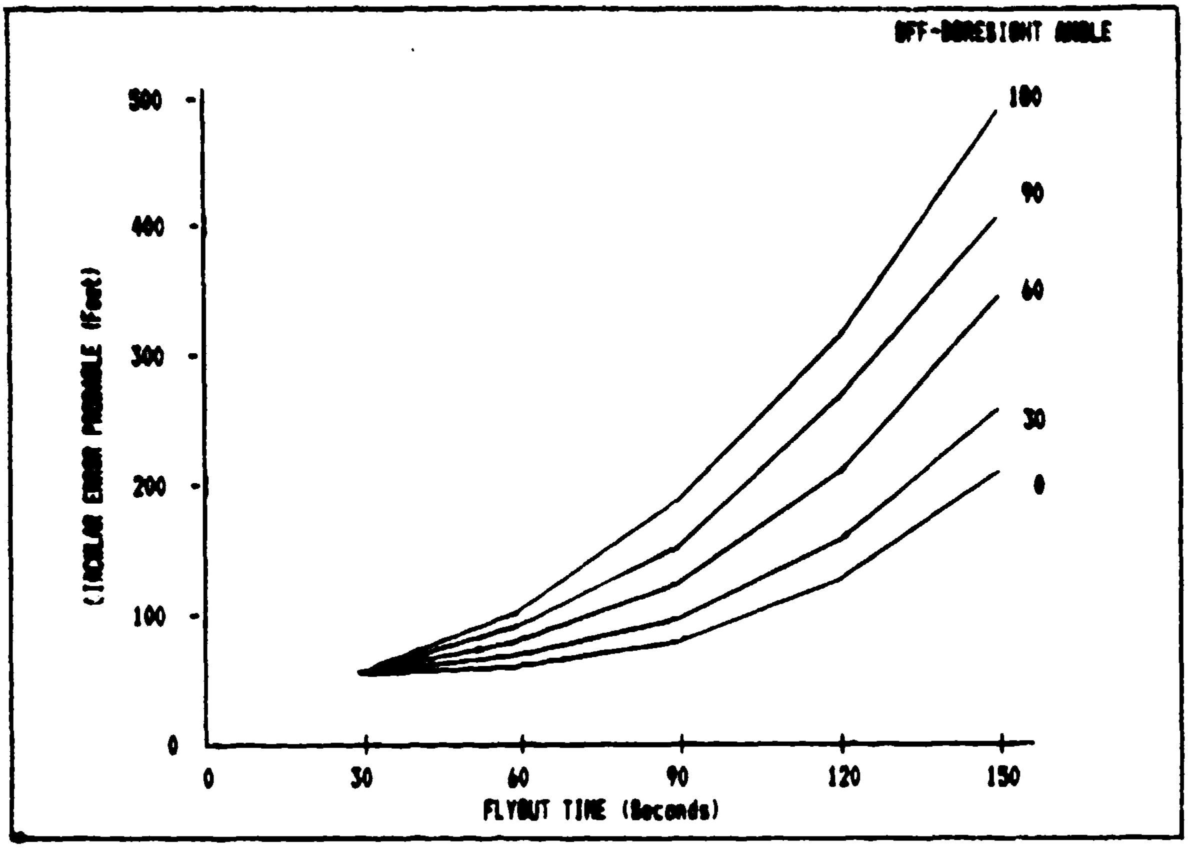


Figure 18. CEP Graph

In order to accurately express the dependent variable, CEP, in terms of the independent variables; the CEP values were transformed. Using this transformation in a regression program resulted in a least squares fit of the data that provided a good approximation of CEP over the entire range of the independent variables. The following equation was then included in the model:

$$\ln(CEP) = 3.15183 + .015838(Time) + .00353(Angle)$$

Attack angle is the direction of the pattern length across the runway with respect to the centerline of the runway. If the attack angle is 0 degrees then the pattern length runs parallel to the runway centerline. The optimum attack angle is not known for the standoff weapon but is expected to be similar to that of the conventional munitions, 30 degrees.

The number of submunitions is a potential variable because it ranges from 30 to 36. The actual number of submunitions is dependent on the number of rocket motors placed in the aft section.

The pattern width and length are expressed in feet and range from 100 to 400 and 400 to 800, respectively. These two factors are considered correlated with respect to DE, because a long and wide pattern will create a very dispersed set of impacts which is expected to decrease the possibility of runway closure, while a short and thin pattern will generate a dense pattern which is expected to increase closure probability given an accurate dispense.

Experimental Design

There were two designs performed on the factors in deriving the DE equation for the standoff weapon. The first design consisted of preliminary runs to determine if any of the five factors, listed in Table VIII, could be eliminated from the equation. This initial design was used to give insight into the most influential factors and minimize the required number of runs, because running AAP would have to be performed by Mr. Jerry Bass of the Armament Weapons Laboratory at Eglin AFB. The second design was used to provide data for the DE equation based on the main factors identified from the preliminary runs.

Minimizing the preliminary runs was done by using a 2^{5-2}_{III} quarter factorial design of resolution III. The factors were arranged according to Table IX.

Table IX

Initial Design Setup

Variable Name	Factor	Alias
CEP	A	-
Attack Angle	B	-
Number of Submunitions	C	-
Pattern Width	D	AC
Pattern Length	E	AB

Design

	1	A	B	C	D	E
1	+	50	0	30	400	800
a	+	400	0	30	100	400
b	+	50	90	30	400	400
ab	+	400	90	30	100	800
c	+	50	0	36	100	800
ac	+	400	0	36	400	400
bc	+	50	90	36	100	400
abc	+	400	90	36	400	800

This design produces aliasing between the main factors, D and E, and the two-factor interactions as well as aliasing between the two-factor interactions themselves. The results of the first design were sufficient to expose the most significant factors necessary to compute the DE equation. Table X depicts normalized treatment effects.

The purpose of the initial design was to reduce the number of input variables. Table X shows that only Factor C, number of submunitions, can be clearly eliminated because the effect of pattern length and width may have been masked by the associated two-factor interactions (21:344). It was decided to eliminate width as an input variable because it shows a smaller percent contribution than length.

Table X

Normalized Factor Results

Variable	Factor	Percent
CEP	A	45
Attack Angle	B	21
No. of Submunitions	C	6
Pattern Width	D	8
Pattern Length	E	20

Final Design. With the number of factors reduced to three, the next step involved formulating input values for AAP runs to provide sufficient data for creating an accurate DE equation. Each of the three factors was varied over a range of values predicted to be employed in the scenario. The actual input values and DE estimates resulting from AAP are listed in Appendix I. Because of limited access to AAP through Mr. Bass, only a limited number of input combinations could be requested.

The graphical results of the data in relation to DE are shown in Figure 19. The effects of CEP appeared to be exponential, while pattern length looked linear. The attack angle effects were more difficult to predict due to the results for angles above 60 degrees. The final step involved regression analysis on the data.

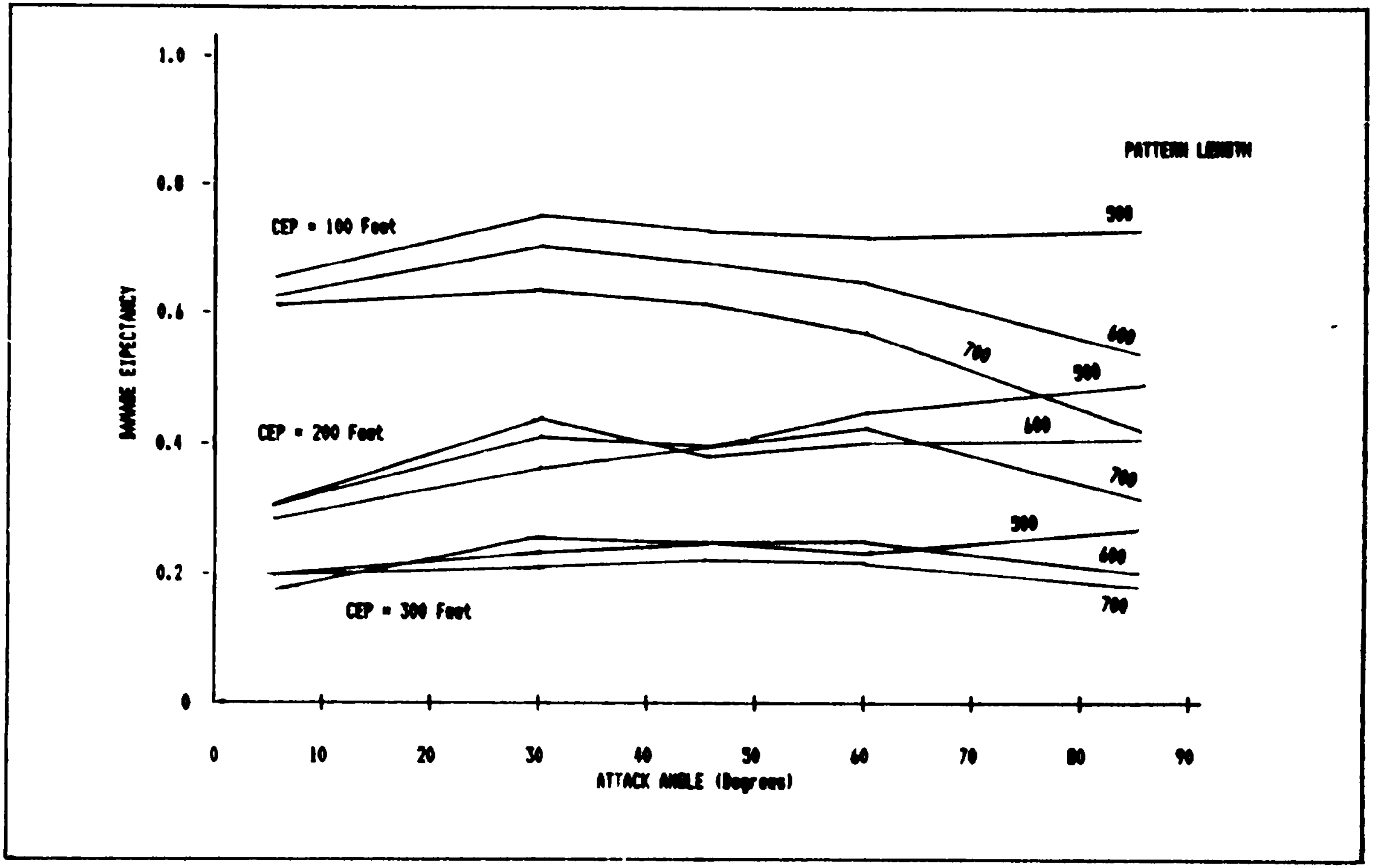


Figure 19. AAP Data

Regression Analysis

Linear regression techniques were used to reduce the data in Figure 19 into a single equation. The desired equation will express the dependent variable, DE, as a function of the input variables: attack angle, pattern length, and CEP. The first step in this activity was to transform the DE probability to eliminate the non-constant variance caused by bounding of DE both above and below. A typical transformation used for probabilities is the "logit" function:

$$Z = \ln(DE / (1 - DE))$$

The ensuing steps taken to fit an equation to the data were continually foiled by the results from runs with attack angles greater than 60 degrees. When the attack angle is large, closure probabilities do not always show the same relationship to the input variables. In the case of a 200 foot CEP and 600 foot pattern length, DE increases for attack angles above 60 degrees. At other CEP values, DE decreases for a 600 foot pattern above 60 degrees. Therefore, that data associated with the large attack angles was deleted from the regression analysis and an assumption was added to the attack scenario.

Since the optimum attack angle is estimated to be 30 degrees and it is expected that missions will generally be planned with attack angles below 60 degrees, the equation is valid for anticipated employment conditions. Therefore, the reduced set of data values should not limit the applicability of the DE equation.

With this assumption and the dependent variable transformation, the independent variables were regressed. Because of non-random residuals and a low R-squared, transformations were used on the independent variables to find a better expression for DE. The following equation was selected:

$$\ln(Z) = -9.05947 + \frac{46.067}{\ln(CEP)} + 5.8725 \times 10^{-8}\,(\text{ATTACK ANGLE})^2 - 9.0149 \times 10^{-7}\,(\text{PATTERN LENGTH})^2$$

This equation provided a high prediction of variance, R-squared equal to .959, and the plot of the residuals gave no indication to reject the assumption of normality. Additionally, the low p-values for the independent variables gave further confidence in the equation to predict DE values.

This equation was incorporated into the simulation logic to provide DE value estimation to create a self-contained model for determination of attrition and runway damage values for standoff munitions.

IV. Model Description

This study initially seemed well suited for continuous modeling because the relationships of the targets to threats are continuously changing with time. Foley and Gress (14) used continuous modeling in their thesis completed in 1984. SLAM (Simulation Language for Alternative Modeling) was their language of choice because of its excellent capabilities when applied in models incorporating a combination of discrete events (threat launches, weapons release, etc) and continuous variables (altitude, aircraft position, velocity, etc). Additionally, SLAM is implemented on computer facilities at AFIT and is taught as a part of the course curriculum. These factors influenced our decision to use SLAM to complete the study.

Within the SLAM version implemented on the AFIT computer, there are one hundred state variables available. Foley and Gress used twelve state variables to represent each aircraft. The present study of standoff weapons requires analysis of the interactions of up to two aircraft and eight standoff weapons with four threat systems. Using twelve variables per vehicle, state variable requirements would exceed the number available. Development of a continuous simulation based on the Foley and Gress model would require extensive modification of the logic or loss of the flexibility to engage four threat systems.

In order to overcome the problems associated with a continuous simulation, a discrete event approximation was adopted. Figure 20 shows a portion of the flight path for a standoff weapon for both a continuous and discrete simulation. Two objectives of the study were to simplify the interactions between the elements of the system and to reduce execution time. Both these objectives are met with a discrete event simulation without significantly affecting flight path accuracy or attrition estimates.

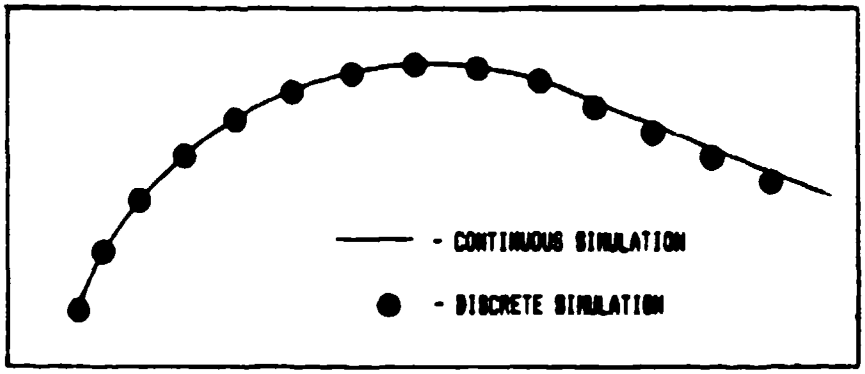


Figure 20. Continuous vs. Discrete Plot

The model examines the relationships between the threats and targets at fixed time intervals. Preliminary designs contained the capability of selecting the time interval. Short time intervals, much less than a second, increased running time without significantly changing the threat engagement statistics found using a one second time interval. Table XI shows how the time interval affected central processor unit (CPU) execution time for two hundred replications of an attack with standoff weapons. Longer time intervals resulted in inaccuracies in the flight path calculations that prevented proper execution of the weapon flight profiles. This early analysis resulted in a decision to use a preset one second interval in the discrete event simulation.

TABLE XI
CPU Processing Time

Interval	CPU Minutes
0.1	130
0.5	60
1.0	20

The discrete simulation, using the networking characteristics of SLAM, proved very flexible for tracking several aircraft and weapons, entities. The entities have up to one hundred attributes available to describe them. The position, velocity, weapon status, and other characteristics of the aircraft are represented by these attribute variables as the aircraft passes from node to node through the network shown in Figure 21. The duration of the activities between the nodes can also be selected to describe the system being modeled. As the standoff weapons flow through the network in Figure 22, the values of the attributes are used to control branching along the network and allow the different weapons to be treated individually. Statistics are gathered by collection of attribute values as they pass through the network. Addition of Fortran coded discrete events, Appendix C, results in a combined network-discrete event simulation that permits calculation of flight profiles and random reactions of the threats.

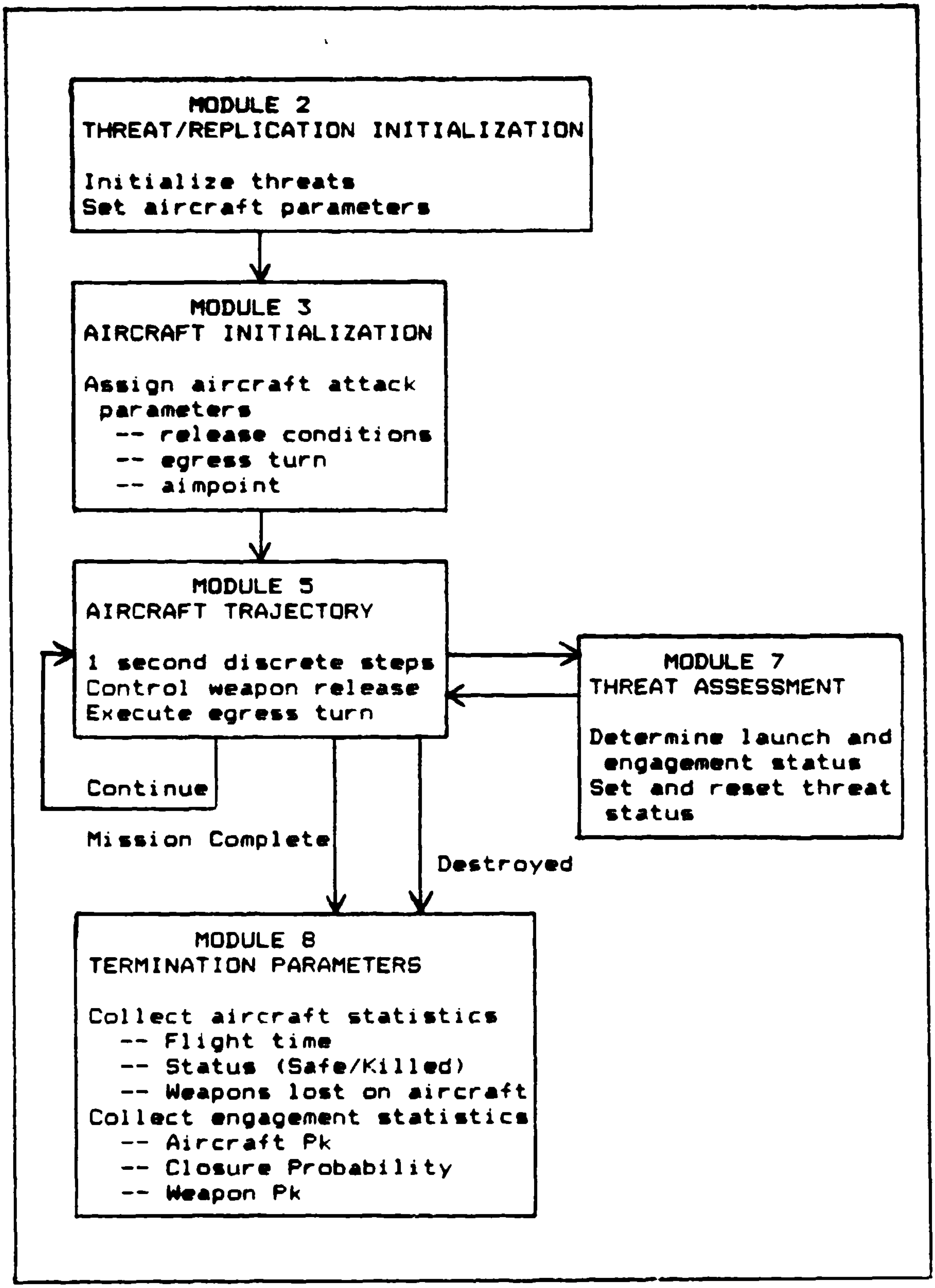


Figure 21. Aircraft Network Flow

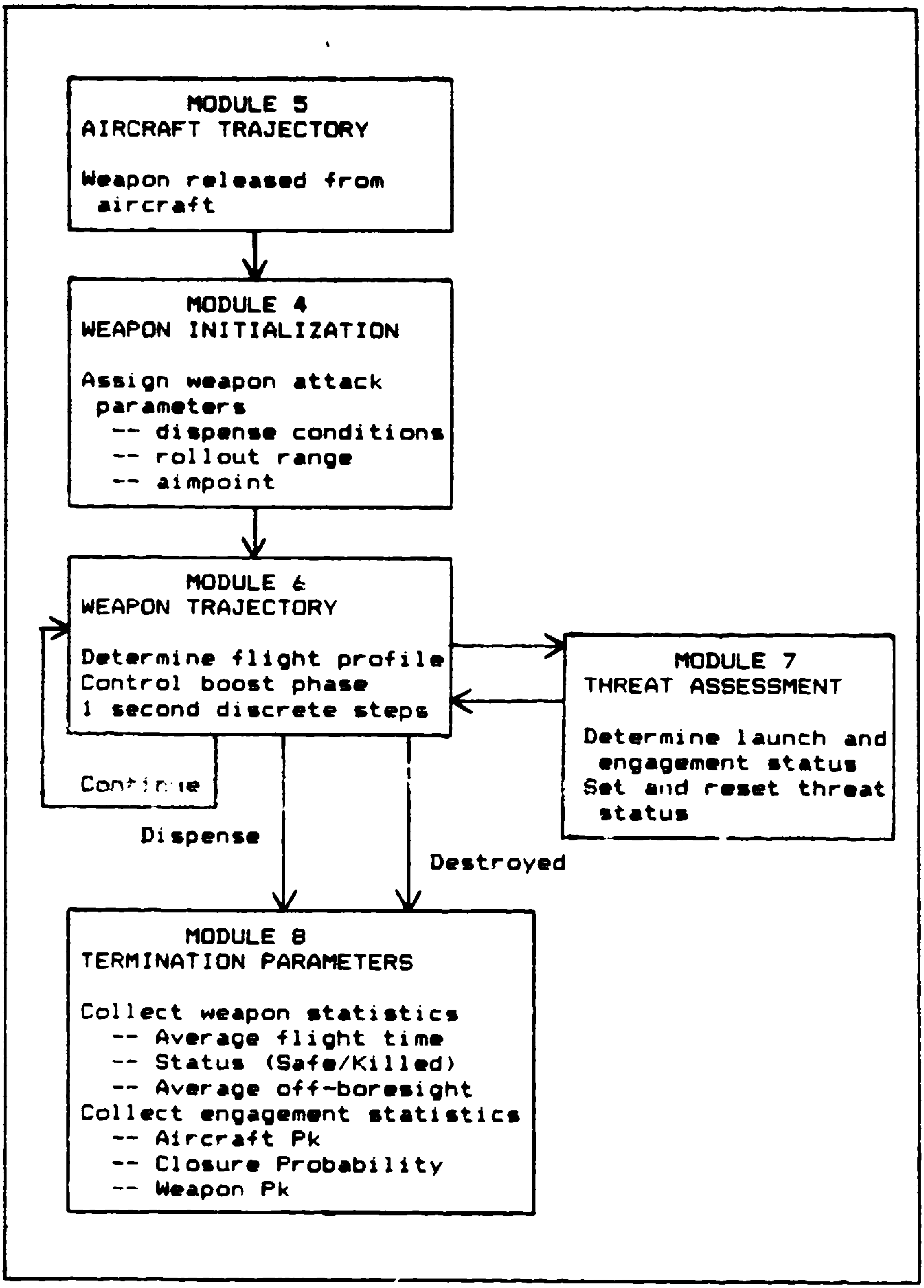


Figure 22. Weapon Network Flow

Assumptions

In order to reduce the scope of the project to a reasonable level, a single scenario was selected for examination and several assumptions made regarding that scenario. The model is designed to allow for variations of the scenario and assumptions. This aided model verification through changes in parameter assignments in the SLAM network and Fortran events.

1. The scenario consists of a two-aircraft OCA attack element penetrating a twenty mile terminal area surrounding a typical Warsaw Pact airfield.
2. Ingress and egress attrition outside the 20 NM terminal area is ignored.
3. Aircraft will not maneuver to evade either the SAM or AAA threat sites.
4. Both aircraft will carry the same weapons load and perform the same attack profile from a choice of level, toss, dive, or standoff delivery.
5. Both aircraft will carry and deliver either two or four standoff weapons released at one second intervals. Conventional weapons are released in a single pass.
6. The direction of attack for the aircraft will be between 030 and 150 degrees true. The aircraft will enter the terminal area established on the proper release course and execute one egress turn following release to exit the area.

7. The aircrew will identify the target, visual or radar, on the first attempt and will release the entire weapons load with a 50 foot aiming accuracy.
8. All conventional deliveries will use an attack angle of 30 degrees to cut the runway.
9. Aircraft will accelerate to 600 KTAS to exit the terminal area after weapons release.
10. The LALD option will be flown as a 30 degree angle off pop-up attack.
11. Standoff weapons will fly a two-turn trajectory to align the weapon on the proper attack angle.
12. The attack angle for the standoff weapons will be between 0 and 60 degrees.
13. The only threat systems modeled in the study are fixed AAA and SAM sites within the 20 NM terminal area.
14. An airborne target must be within a SAM threat envelope for a minimum of five seconds prior to any launch determination.
15. Although radar cross section, maneuver capability, and other factors may differ with the various weapons configurations, kill probabilities are the same for all aircraft.
16. AAA sites will engage a target on each attack and fire all its rounds on that target unless the target flies out of range or is destroyed.

SLAM Network Code

To provide for multiple replications for each attack option, the SLAM program is designed to create multiple attacks separated by a time interval longer than the duration of each attack, approximately two hundred seconds. Each replication begins with creation of the attack aircraft and resetting of the variables representing the threats. With this method, statistics are collected and stored over the entire set of replications and presented in a single output format. There are eight modules in the SLAM networ' Appendix B, that provide for execution of the attack and collaction of statistics.

Module 1 - Entity Count. The only purpose of this module is to determine the number of entities that will pass through the network in each replication. It is called at time zero and sets a global variable based on the tactic selected.

Module 2 - Threat/Replication Initialization. This module establishes parameters for the attack. The parameters are changed during an attack and then reset to the required initial values prior to the next replication. This method allows for collection of statistics over the series of attacks and presents averages in a single output format.

Module 3 - Aircraft Initialization. The aircraft can fly four different weapons delivery profiles with conventional weapons. Each profile is characterized by attribute values associated with the aircraft. For example, the release range is set much larger for the toss maneuver than for a level attack. These attributes are set using conditional branching to the proper nodes for each attack option. Once initialized, the aircraft entities proceed to the module that controls the flight path and weapons delivery calculations.

Module 4 - Weapon Initialization. Parameters for the standoff weapons are set in this module. Conventional weapons have such short times of flight that their trajectories are not calculated. Just as the aircraft have attributes that characterize the attack, standoff weapons are assigned values representing attack heading, aimpoint, and rollout range. Individual assignment of weapon attributes allows for wide flexibility in profiles and aimpoints. Standoff weapon entities are then branched to Module 6 for profile determination and trajectory execution.

Module 5 - Aircraft Flight Path. This module updates aircraft position and determines when weapons release conditions are met. Conditional branching is used to provide for velocity adjustments, selection of release modes, and termination of the attack. A threat assessment routine common to both the aircraft and the weapons, Module 7, is performed as the aircraft entity flows through this module.

Weapons release is divided into two categories, standoff and conventional. Standoff weapons release is performed with a one second interval between each release and up to four weapons per aircraft. As the weapons are released, the pylon status (bombs remaining) is updated and an egress maneuver is executed when the pylons are empty. Conventional weapons are modeled in much the same manner except all weapons are released simultaneously. Acceleration to egress speed and turn to egress heading occur after release of all weapons.

Module 6 - Weapon Trajectory. The standoff weapons fly through the terminal area in a manner similar to the aircraft. Weapon velocity changes to reflect the variations resulting from ignition and burnout of the boost motors. The velocity changes are modeled after Figure 23 obtained from Brunswick Corporation (30:4-4).

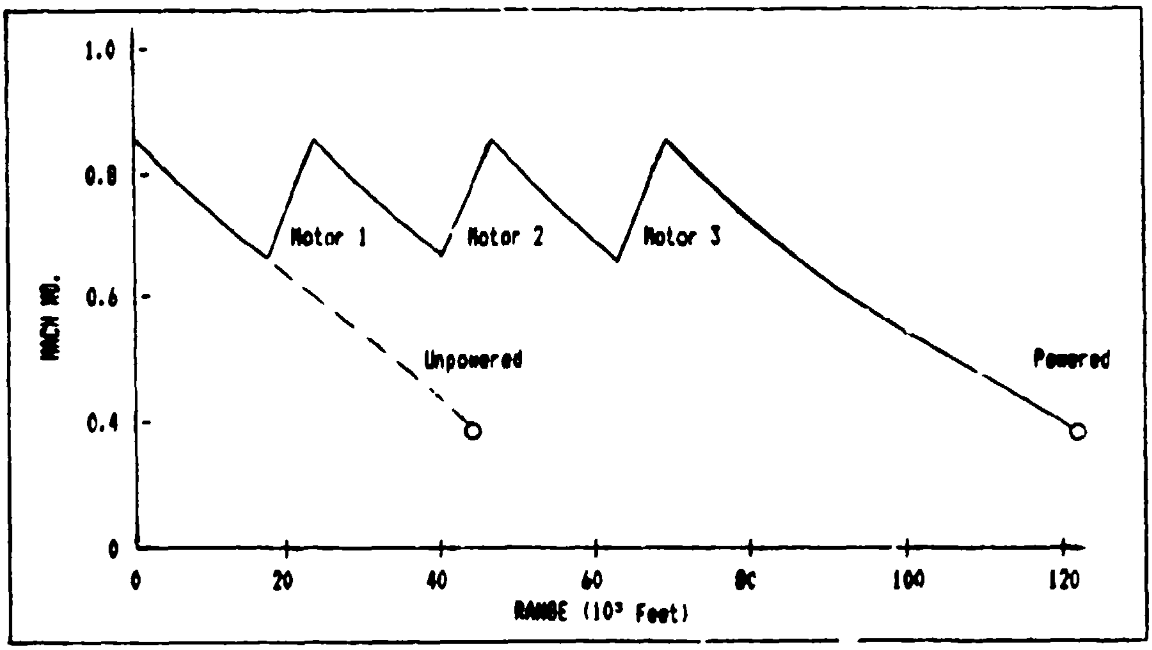


Figure 23. Standoff Weapon Velocity Profile

The trajectory of the weapons is modeled with a slight climb from release altitude to a specified cruise altitude. The weapons perform up to two turns to position themselves on the dispense heading at a specified distance from the aimpoint. Deceleration, due to aerodynamic drag, is increased when the weapon is in its constant radius turn. Threat assessment is performed in the same module, Module 7, as it is for the aircraft.

<u>Module 7 - Threat Assessment</u>. This module determines attrition statistics and collects overall attack kill probability and effectiveness of the individual threats. The network flow in Figures 21 and 22 shows that this is the only module that is executed from within another module. All other modules follow after completion of the execution of the preceding section of the SLAM network.

The first step is to accumulate time in each threat circle for the weapons and aircraft. After a minimum time in the threat envelope has elapsed, launch status for each threat is determined with random number draws. The results of the engagements are calculated in a Fortran subroutine called by this module. If the target is killed, an attribute value is changed to flag the target as destroyed which terminates the entity upon return to the flight path or trajectory module. To preclude multiple kills on the same target, an entity is flagged as destroyed at the time of the engagement if the attack is projected to be successful. Threat availability is reset with global variables, however, after the SAM engagement is completed. Target status statistics are collected to provide information regarding which targets were engaged, time of flight of the targets, and pylon status for the aircraft.

Module 8 - Termination Parameters. Overall mission attrition rates for the aircraft and weapon need to be collected only once during the series of replications. Additionally, since entities are terminated for two reasons, mission completion and destruction by a threat; statistics must be collected after completion of the series of replications to insure all entities are included. To accomplish this, the program branches the last entity to the statistics subroutine to calculate attrition and statistics.

Fortran Program

The Fortran code consists of the main program and six subroutines: INTLC, OTPUT, EVENT, CIRCOORDS, ROLLOUTS, and GRIDLOC. The main program provides overall model control and executes the SLAM portion of the model. The INTLC and OTPUT subroutines are required in the program even if the subroutine consists of only a return as in the OTPUT routine in this model. INTLC is called by the SLAM control statements only once to establish initial variable values prior to the first replication. The EVENT subroutine is called by the SLAM network when entities pass through an Event node. A value associated with the node is used by EVENT to select the required portion of the subroutine.

GRIDLOC, CIRCOORDS, AND ROLLOUTS are subroutines called by the EVENT subroutine to perform specific standoff weapon trajectory calculations.

EVENT. This is the largest section of the Fortran coding. Aircraft flight path and weapon trajectory calculations, threat engagements results, and output print routines are executed by the fourteen independent events listed in Table XII. When the EVENT subroutine is called from the SLAM network, a conditional statement branches to the line number of the appropriate event. Upon completion of the event, execution is returned to SLAM.

Table XII

Events Log

EVENT	FUNCTION
1	Weapon Profile
2	Fly Weapon
3	Print Dispense
4	Locate Entry Point
5	Print Attributes
6	Fly Aircraft
7	Print Release
8	Closure Probability
9	Print Location
10	Threat Engagement
11	Engagement Site 1
12	Engagement Site 2
13	Engagement Site 3
14	Engagement Site 4

Event 1-Weapon Profile. This event is called by the SLAM network to determine the weapon's flight profile parameters. The profile can be either two turns in the same direction or two turns in opposite directions as shown in Figure 24. For this study, the weapons fly a preprogrammed profile that is divided into the following four phases:

1) An immediate climbing turn toward the target.
2) Level off and rollout on an intermediate heading.
3) Second turn to rollout on the proper dispense heading.
4) Level flight to the dispense point.

Given only the release and dispense conditions, the flight profile is determined. Subroutines CIRCOORDS and ROLLOUTS contain the logic required to calculate the parameters.

<u>CIRCOORDS</u>. This subroutine determines the directions and centers of the turns which determine the profile code. A description of the elements of the trajectory geometry is depicted in Figure 25. The release point coordinates are the aircraft position at the time the SLAM logic determines weapons release conditions are met. The coordinates of the rollout point are calculated with the desired rollout distance and dispense heading. Based on these two points and the headings desired at these points, the centers of the four circles shown in Figure 25 are calculated. The appropriate headings are tangent to the circles at the release and rollout points. Point A and Point B identify the endpoints of the intermediate course. Since only one circle at each end of the intermediate course is used to fly the weapon's trajectory, this routine determines which circles to use.

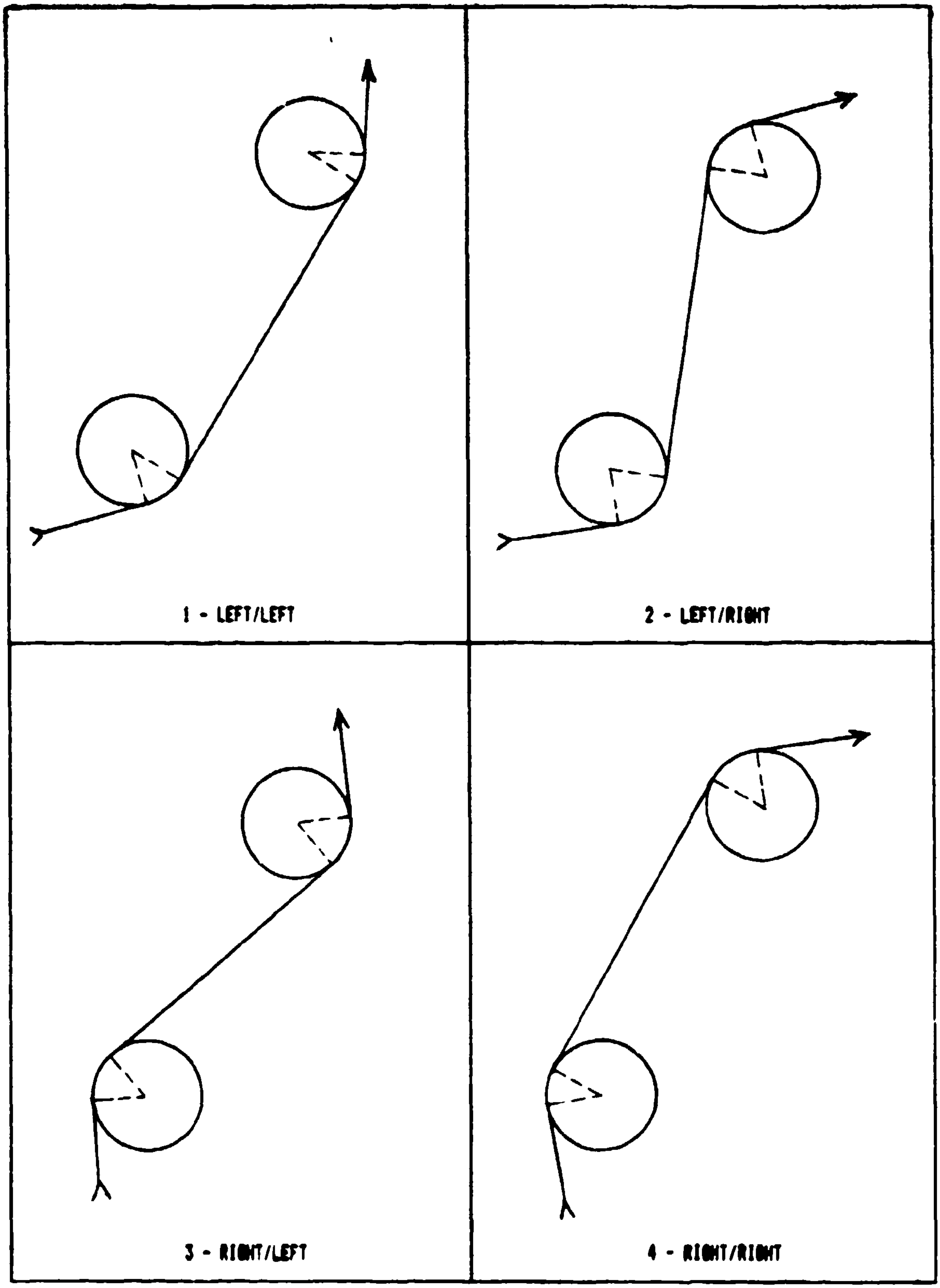


Figure 24. Weapon Trajectory Profiles

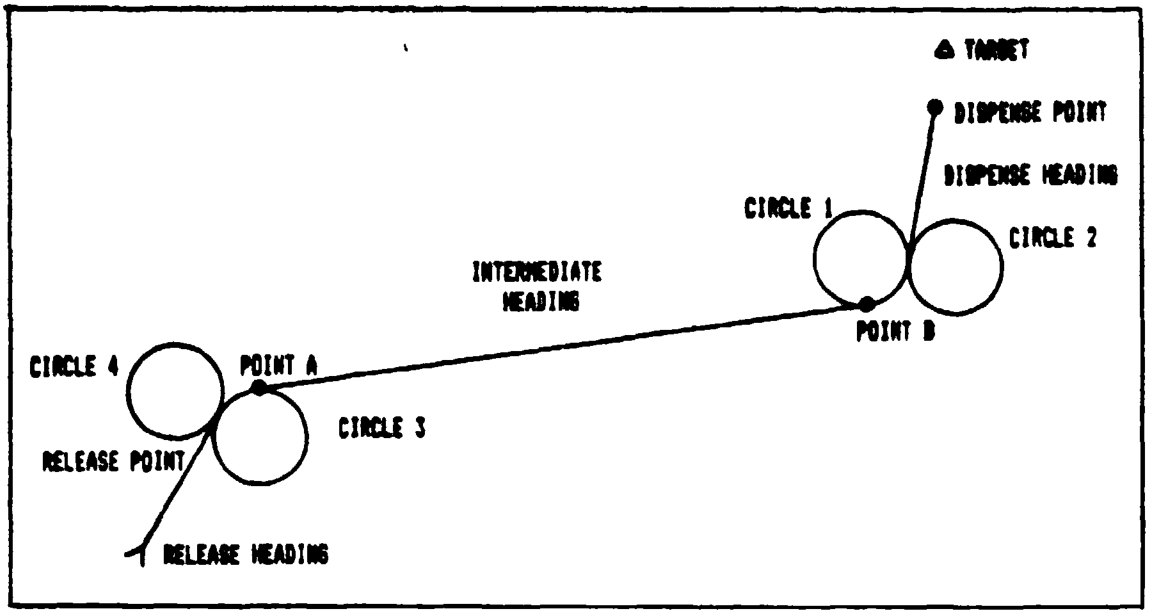


Figure 25. Trajectory Geometry

The direction and center of the first turn is selected by choosing the circle whose center is closer to the target (Circle 3 or Circle 4). The program then assumes the second turn will be in the same direction as the first turn and selects the appropriate circle. The slope of the line between Point A and Point B is the same as that between the selected circle centers. Comparing this slope with the slope of the line from the rollout point to the dispense point determines if the assumed second turn is correct. In Figure 26, a Right/Right profile is selected because the slope of the line from Point A to Point B is greater than that of a line from rollout to dispense. When the assumption is correct, the profile characteristics are stored in the weapon's attributes.

When the assumption is incorrect, the other circle is selected for the second turn as in Figure 27 and the appropriate attribute values are stored. These attribute values are then used by the ROLLOUTS subroutine.

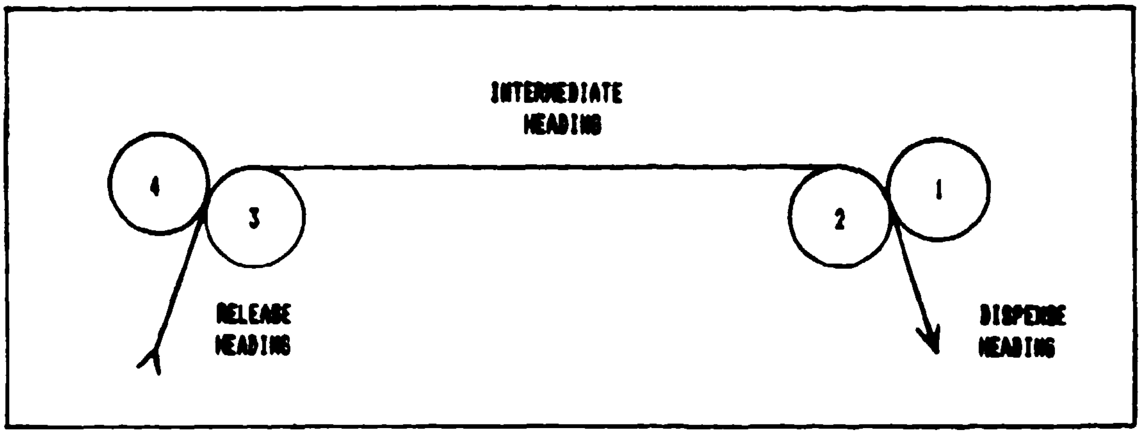


Figure 26. Same Turn Directions

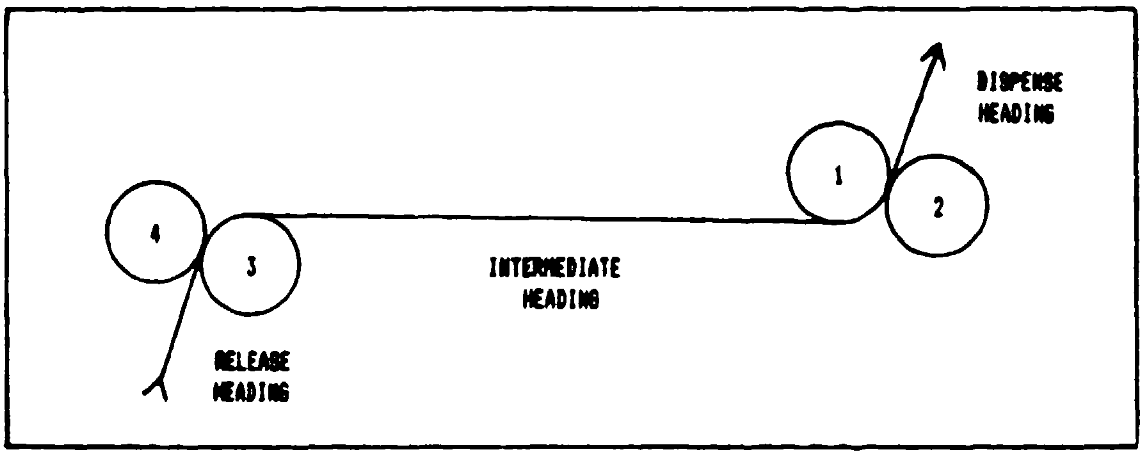


Figure 27. Opposite Turn Directions

ROLLOUTS. The intermediate heading is calculated based on the weapon's profile code. For turns in the same direction (Left/Left or Right/Right), this is simply the arctangent of the slope of the line between the selected circle centers as in Figure 28.

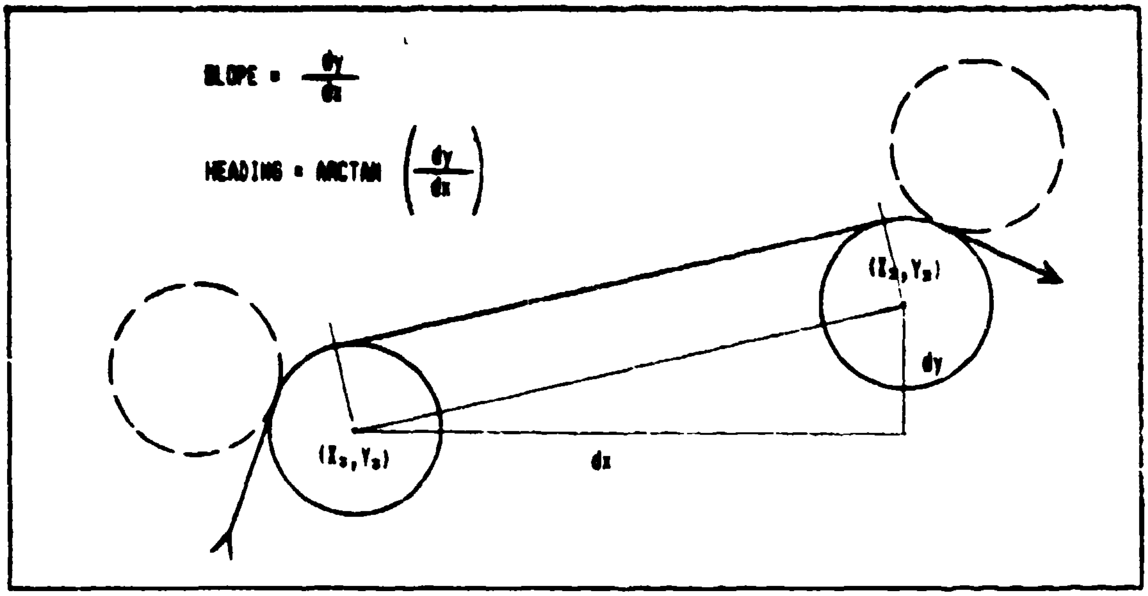


Figure 28. Intermediate Course - Same Direction

Figure 29 shows a profile where the turns are in opposite directions. To find the intermediate heading, a Base Heading is calculated using the centers of the two selected circles. Circle 5 is then drawn to establish the triangle, ABC. Using the relationship between Side 1 and Side 2, angle Ø is found and added to the Base Heading for a Right/Left profile. For a Left/Right profile, the method is the same with the exception that the angle is subtracted from the Base Heading. The angle, measured in radians, is used by the program code for all flight path calculations.

<u>Event 2-Fly Weapon.</u> This event updates the weapon's position. Calculation of the new position is accomplished differently based on whether or not the weapon is turning. During level flight, the weapon can be in either of two phases of flight, intermediate leg or final

dispense course. While on the intermediate heading, a check is made to find out if the weapon has intercepted the second turn radius. When it does, attribute values are changed to indicate that the weapon has begun the turn. Distance to target is calculated while the weapon is rolled out on dispense heading and flight path calculations are terminated at the dispense point.

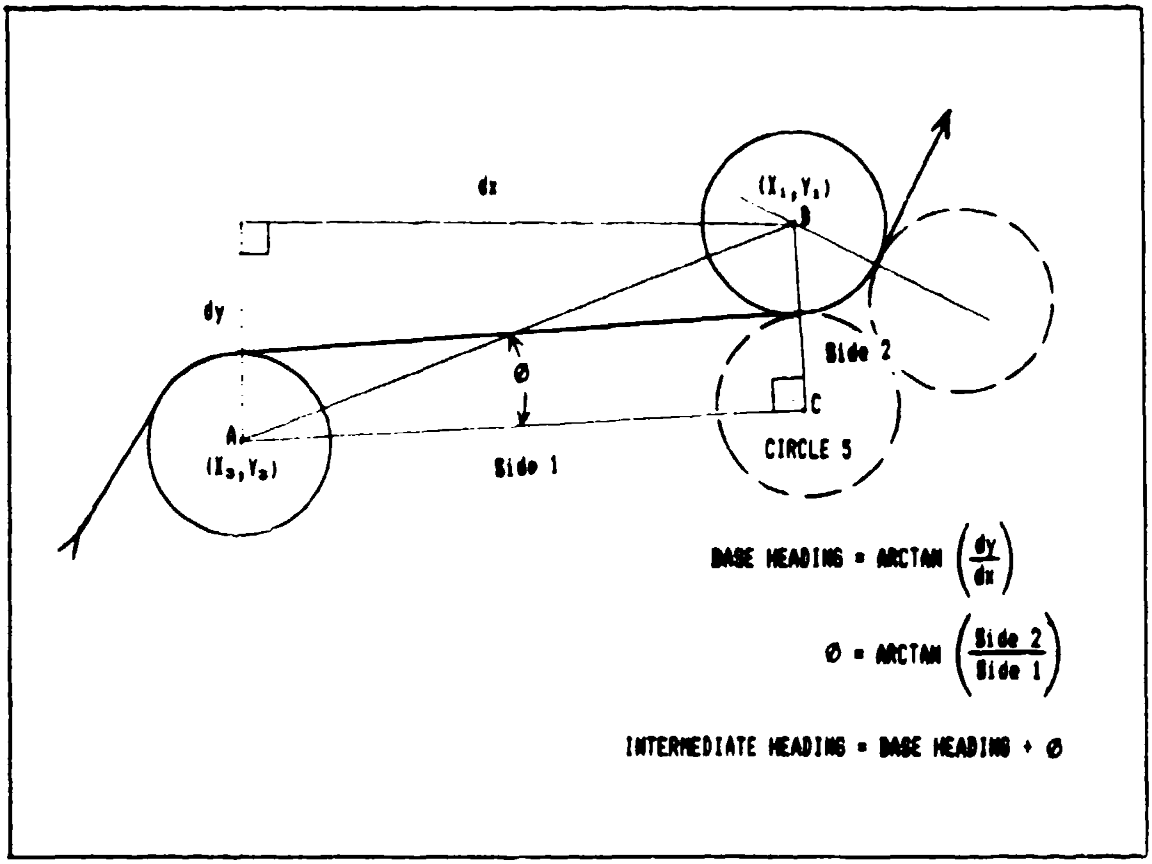


Figure 29. Intermediate Course - Opposite Direction

Turning flight is also divided into two potential phases, first turn or second turn. If the weapon is in the first turn, a comparison of the current heading and intermediate heading is made each time the event is called to determine rollout, Point A. When the rollout heading is reached, attribute levels are set to indicate straight and level flight and the current heading is set. In the second turn, the logic is the same except the current heading is compared with the dispense heading to find the rollout point.

Event 3-Print Dispense. This event is called when a weapon reaches its dispense conditions. The print statement was used during verification of the trajectory calculations and is not used when running multiple replications. It is included in the final model as a comment statement that can be converted to an executable statement if further flight path verification becomes necessary. This technique is used throughout the Fortran coding to provide simpler program code modification when required. The main purpose of this event, however, is to calculate average flight times and total degrees of turn for each weapon reaching dispense. These averages are used as inputs for CEP calculations in Event 8.

Event 4-Locate Entry Point. Based on bearing to the target, this event determines the coordinates of the point where the aircraft enters the twenty nautical mile terminal area. For conventional tactics, the aircraft enters the area on a release heading calculated for the specific aimpoint on the runway assigned to the aircraft. For a standoff attack, the heading is previously assigned in the SLAM network.

Event 5-Print Attributes. This event, used during flight path verification, prints all weapon attribute values at release and when destroyed by a threat. This feature was valuable during the initial phases of the study to verify the proper selection of weapon profile and calculations made in Event 1.

Event 6-Fly Aircraft. The aircraft position, heading, and pitch attitude are updated in this event. Altitude calculations are common for all tactics. Conventional weapon tactics are represented by pitch and heading changes that result in the desired weapon delivery maneuver. Level and Toss maneuver calculations are accomplished with reference to distance from the aimpoint. The LALD maneuver begins at a prescribed distance from the target and further parameter changes are determined as a function of time from the beginning of the maneuver.

Event 7-Print Release. Used during verification, this event flags weapons release in the output.

Event 8-Closure Probability. This is one of the primary measures of merit of the study. It is presented as the probability that a two-ship attack element will close the runway. Matrix identifiers are used to demonstrate the logic required to look up weapon DE. Probabilities for current conventional munitions can be obtained from JMEM to replace the matrix identifiers. Unlike the conventional weapons, DE values are calculated by the simulation. This event performs the required CEP and DE calculations. For standoff weapons only, damage expectancy includes estimated weapon attrition.

Event 9-Print Location. This is the print routine used most often during flight path verification. It prints attribute values at one second time intervals for each weapon or aircraft in the simulation.

Event 10-Threat Engagement. This event determines threat engagement status for the four terminal area threats simulated in this scenario. The two AAA sites, Threat 3 and Threat 4, are modeled with identical logic while the SAM sites, Threat 1 and Threat 2, contain a minor difference in engagement logic. All threats first require evaluation of time within the effective range of the threat.

Evaluation of missile launch probability for Threat 1 only occurs if the site is not currently engaged with another target and a minimum time in the threat ring has elapsed. When these conditions are met, a random number is drawn and compared to the appropriate launch probability for the aircraft or weapon. If a launch is executed, the site is flagged as engaged for a period of time representing missile flight time and confounding delay prior to the next engagement. The only difference in Threat 2 is that multiple targets, up to four, can be engaged simultaneously.

The two AAA sites are identical in engagement logic. Each threat independently selects a target to engage for each replication. Once the target is selected, the site engages the target with a maximum of six bursts. The bursts are fired with a one second cooling interval between each burst.

Event 11-Engagement Site 1. This event determines the effectiveness of a SAM engagement with current enemy capabilities. It contains logic that establishes altitude and electronic counter measure characteristics of the entity at the time of the engagement and selects a probability code from the proper grid using the GRIDLOC subroutine.

Each engagement consists of a salvo of two missiles launched at the target. Separate missile and launch control reliability determinations are made for each missile prior to assignment of missile kill probabilities. If a missile fails to reach the target, the probability of kill is set to zero for that missile. If the missile does complete the engagement, a kill probability is calculated and modified if the entity is in a turn. If the entity is a weapon, the kill probability is divided by a factor representing the increased difficulty expected when engaging a smaller target. A random number draw for each missile is then compared to each of the calculated missile kill probabilities. The entity status is flagged as killed if either comparison indicates a hit.

Event 12-Engagement Site 2. The logic in Event 11 is duplicated in this event for the SAM with out-year capabilities.

Event 13-Engagement Site 3. Engagement effectiveness logic for a AAA site is contained in this event. The probability of kill for a single burst of rounds is calculated based on target range and altitude. As in the SAM engagements, the probability of kill may be decreased based on entity characteristics, and a comparison with a random number is used to determine the entity's status.

Event 14-Engagement Site 4. This event duplicates the logic in Event 13 to represent another AAA site located on the airfield.

GRIDLOC. This subroutine is used by the SAM engagement routines to locate the target relative to the missile site for determination of the missile kill probability.

The first step in this process is evaluation of the entity's bearing and range to the threat. With this information and the heading of the target, the radius of closest approach (RCA) and downtrack range are calculated and used in Figure 30 to determine track and range block.

A track number, based on RCA, and a range block, based on the downtrack range, are calculated to be used as index variables for the kill probability matrix. The altitude and ECM are previously set and are used to fully describe the engagement conditions and position of the target. After determination of the kill probability code from the matrix, this subroutine then returns to the SAM event for calculation of engagement results.

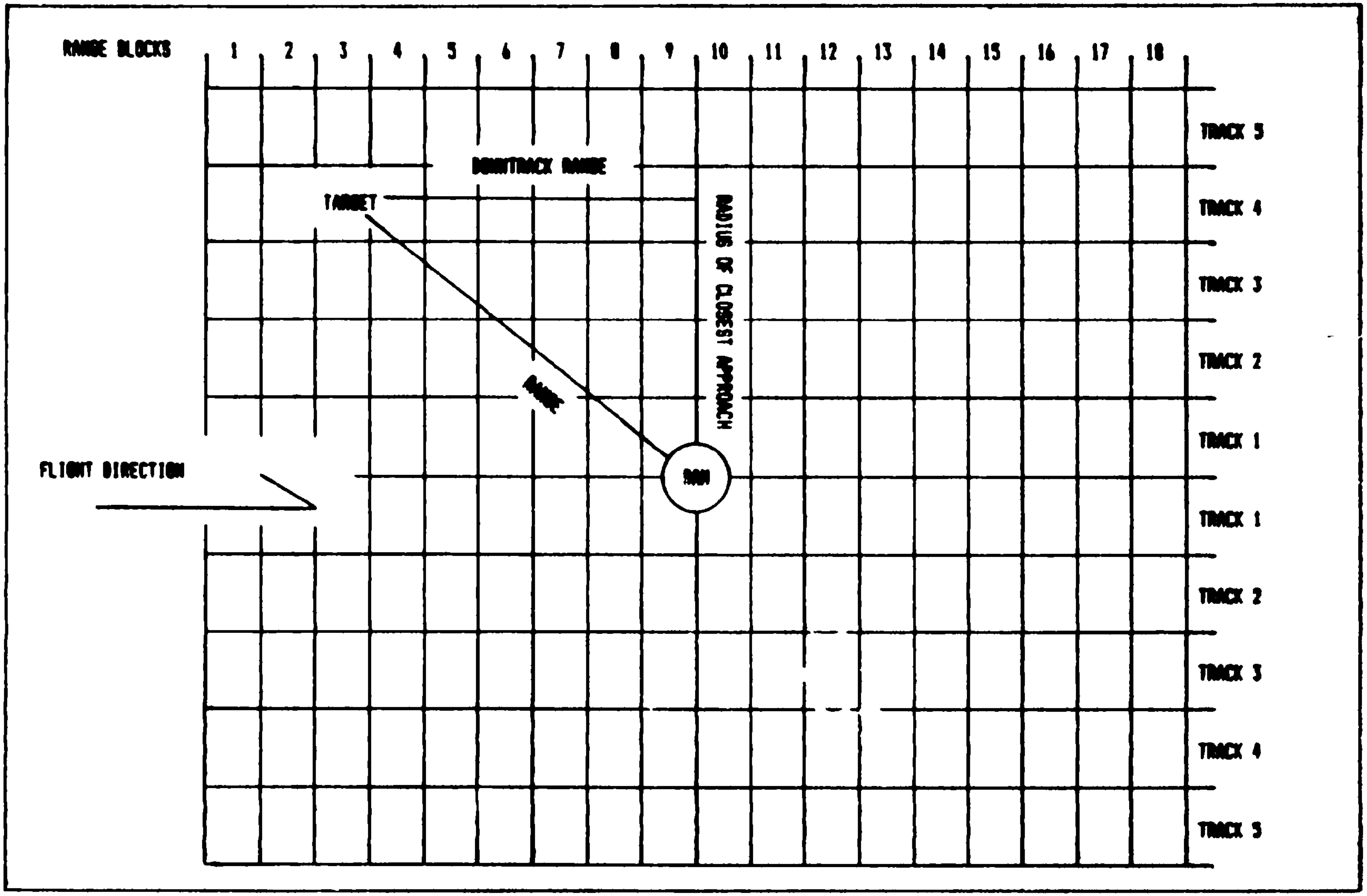


Figure 30. SAM Engagement Geometry

V. Verification and Validation

These two steps in model development are quite different; but, both have the same goal, increase model credibility. The results of any study will not be used unless it can be demonstrated that the model captures the major characteristics of a system and accurately measures the interactions between the system elements. Therefore, it must be shown that the model not only performs as it is intended (verification), but also represents the real-life system (validation).

Verification

To simplify the verification process, the model was constructed of individual logic segments. Each segment was verified prior to implementation in the model to permit a thorough analysis of the logic without complications created by the other elements of the system.

The segments can be divided into two main categories, flight path calculations and threat engagement simulation. Verification of the flight paths of the aircraft and weapons relied primarily on comparisons with hand-calculated values and position plots. The Monte Carlo simulation of the threat engagements, however, required statistical analysis to verify the logic.

Flight Path. The model simulates both the flight path of the aircraft and the flight path of the standoff weapons. The position, altitude, velocity, and other flight characteristics are determined for the aircraft while it is within the 20 NM threat ring. The weapon's flight path (trajectory) is modeled from the time of release from the aircraft until dispense of the submunitions.

Aircraft. The four tactics the aircraft can fly during an attack on the airfield were coded and verified individually. Appendix H contains the maneuver portion of the three conventional tactics. The ingress and egress portions are constant altitude, constant heading segments and are similar for all three conventional tactics as well as the standoff tactic. Appendix G contains an entire flight path verification for the standoff tactic.

Verification of these flight paths consisted of plotting the coordinates on the printouts against the intended flight path. When an aircraft enters the terminal threat area; it is assigned a heading, velocity, and pitch attitude. The position of the aircraft one second later is fully described by applying appropriate trigonometric relationships to the velocity vector of the aircraft. Figure 31 through Figure 33 show how the discrete approximation of the aircraft flight paths agree favorably with the projected flight path. In the case of the egress turn, the flight path differs slightly from the planned turn, but this was not considered significant because of the relatively small variations and the fact that variations will also occur in the real system.

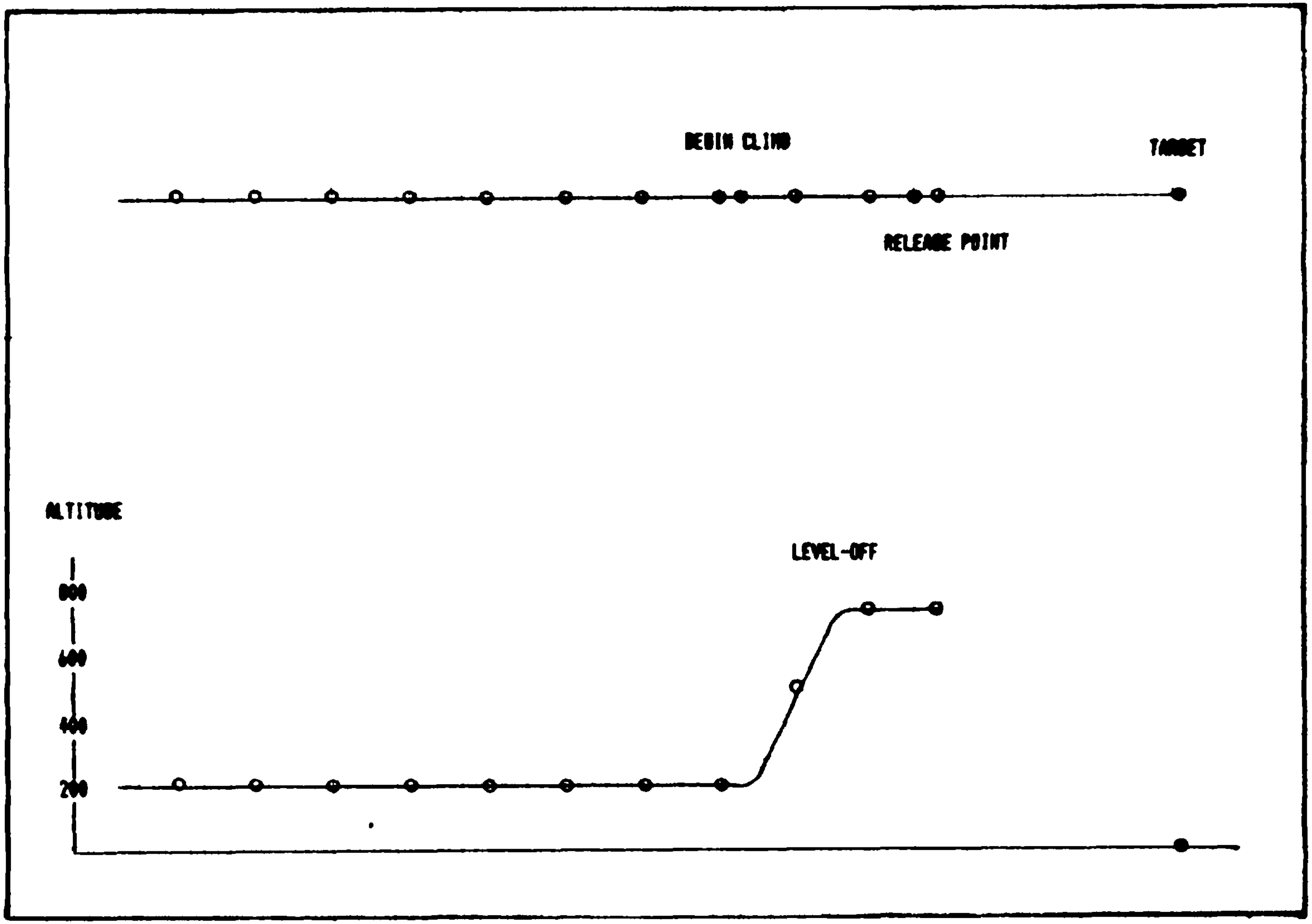


Figure 31. Level Delivery Plot

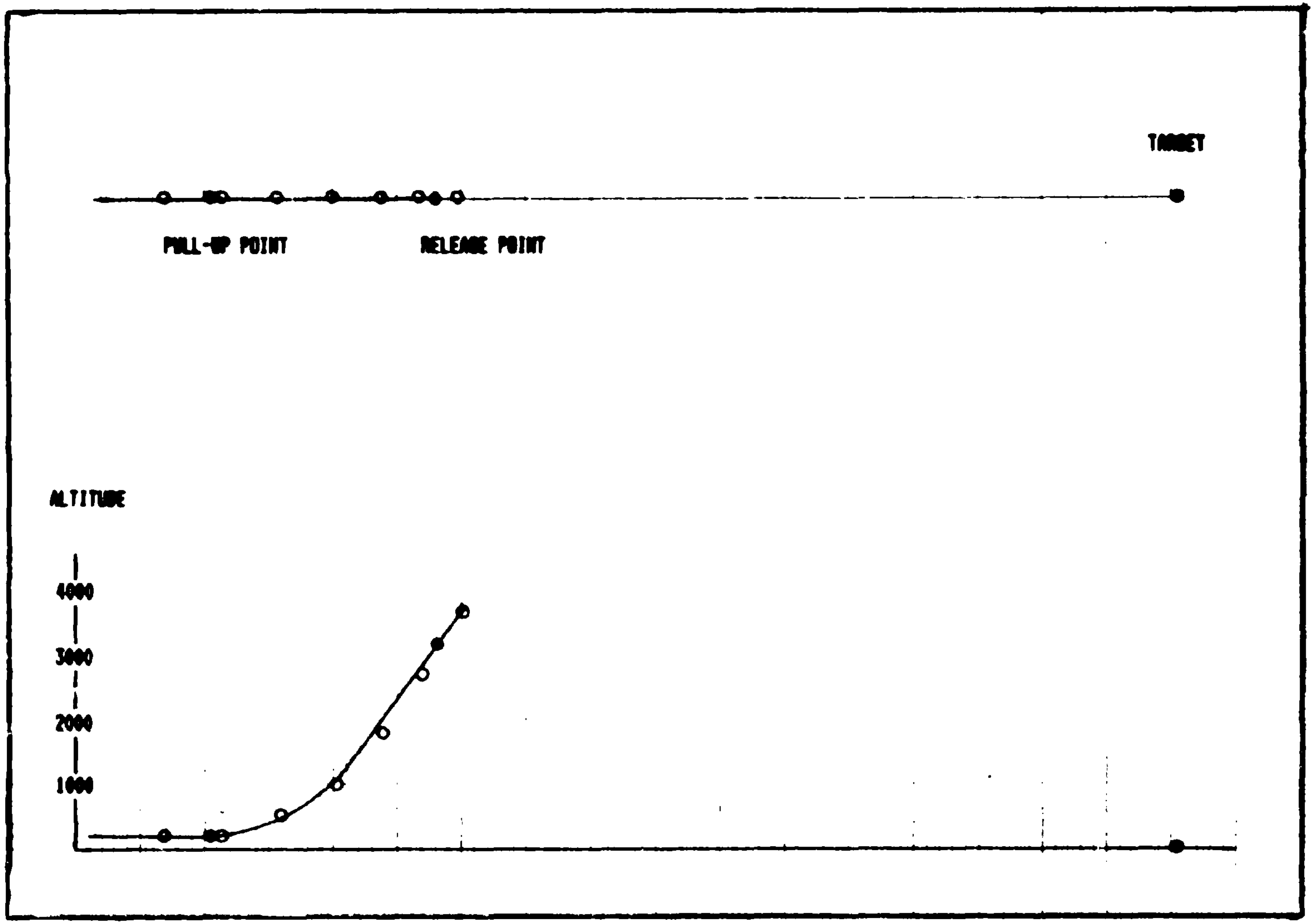


Figure 32. Toss Delivery Plot

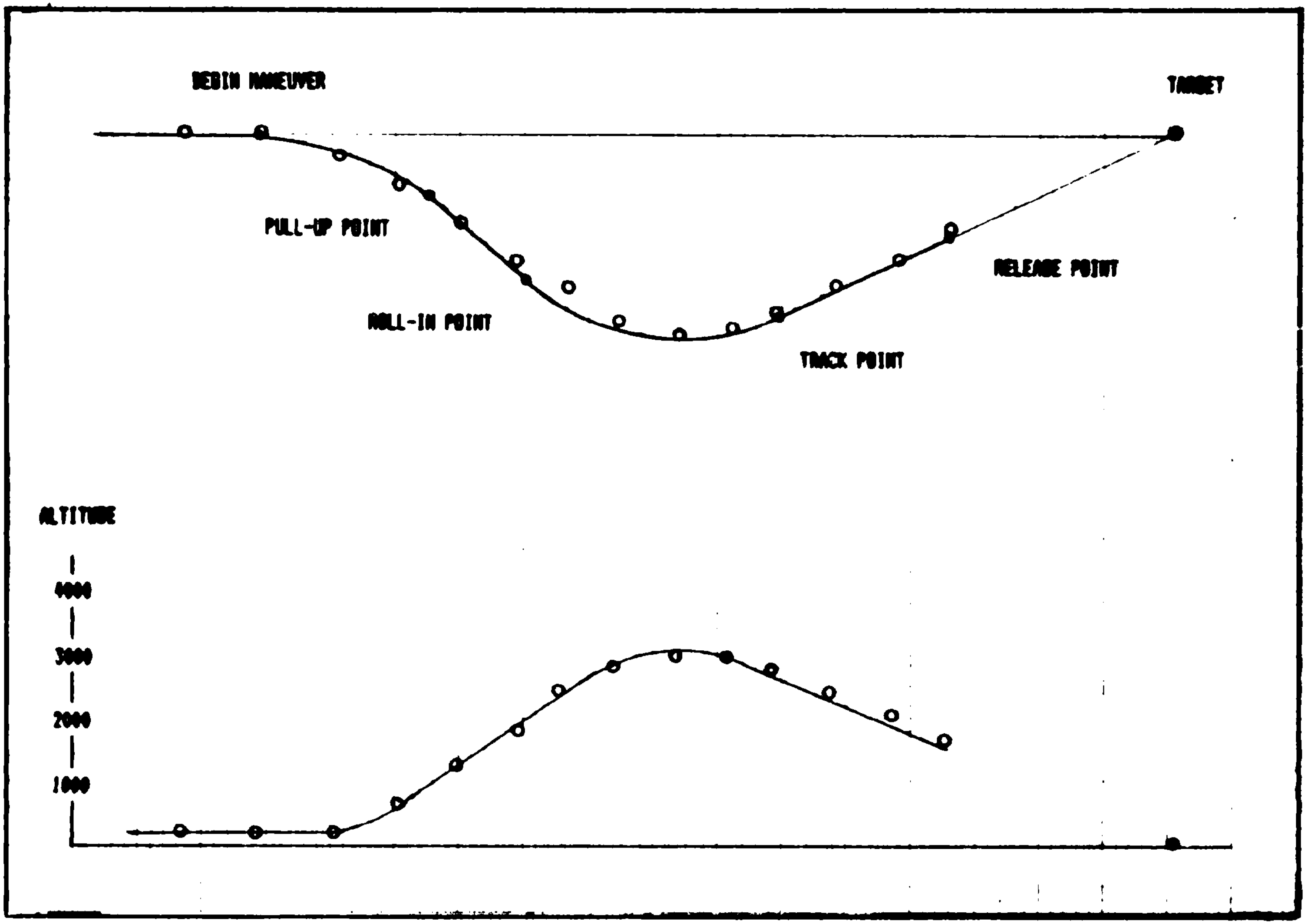


Figure 33. LALD Delivery Plot

Standoff Weapons. The standoff weapons presented more of a problem during verification. The trajectory of the weapons is not fully described by the input parameters. Given just the release conditions and dispense conditions, the coordinates of the turn points and direction of the turns are calculated by the model. Table XIII lists trajectory inputs available at the time of weapon's release. From these values, the values in Table XIV are calculated to describe the trajectory.

Each of the values determined at release had to be verified to ensure that the weapons were flying the proper trajectory. During the early stages of development, a hand-plotting process was used to verify the trajectory values calculated at release. The circles described in Section IV were drawn and the coordinates of the circle centers compared to the simulation values. With the variety of release conditions, this process was too time consuming and another method was required.

To simplify the process, the logic was written in Applesoft Basic and run on an Apple IIE microcomputer using the graphics capability. With this program, the input parameters were varied to exercise the trajectory logic using the graphics to give a visual display of the trajectory. This method quickly identified logic errors in the early versions of the model that caused the weapon to turn the wrong way and never reach the dispense point. The graphical display immediately identified the problem while, on the other hand, looking at a listing of coordinate values may not have uncovered the problem until much later. Using this basic program, profile selection was verified and the logic was converted to Fortran for integration into the model.

Table XIII

Weapon Trajectory Inputs

Velocity
Release heading (True)
Standoff range
Dispense heading (True)
Rollout range
Dispense range
Release X-coordinate
Release Y-coordinate
Target X-coordinate
Target Y-coordinate

Table XIV

Trajectory Values Calculated at Release

Profile code
Current heading (radians)
Intermediate heading (radians)
Dispense heading (radians)
Turn status
Turn number
First turn center-X
First turn center-Y
Direction of first turn
Second turn center-X
Second turn center-Y
Direction of second turn
Rollout X-coordinate
Rollout Y-coordinate

The trajectory of Weapon 11 in Appendix G is plotted in Figure 34 against a hand-calculated continuous flight path. The figure also shows the four circle centers and other points calculated in the profile selection process. Although minor deviations exist, the discrete event simulation closely models the projected trajectory. As in the case of the aircraft, these variations are not unlike variations expected in the system being modeled and do not adversely affect the model's representation of the system.

Threat Engagement. Because of the stochastic nature of this aspect of the model and the underlying distributions that describe the system interactions, verification required the use of different methods.

SAM. Engagement probability was the first factor examined. The model was run with a zero probability of kill to allow the aircraft and weapons to fly through the entire threat envelope. This increased the number of engagements enhancing the opportunity to identify problems.

SLAM has the capability to follow an entity through the system using the trace feature (25:156). During the early development of the engagement logic, a trace showed that entities were being engaged as expected and threat systems were being tied up for the expected duration of the attack. In the case of the out-year system which could engage more than one target, the trace showed simultaneous engagements, as expected.

Further verification of the SAM engagement logic was

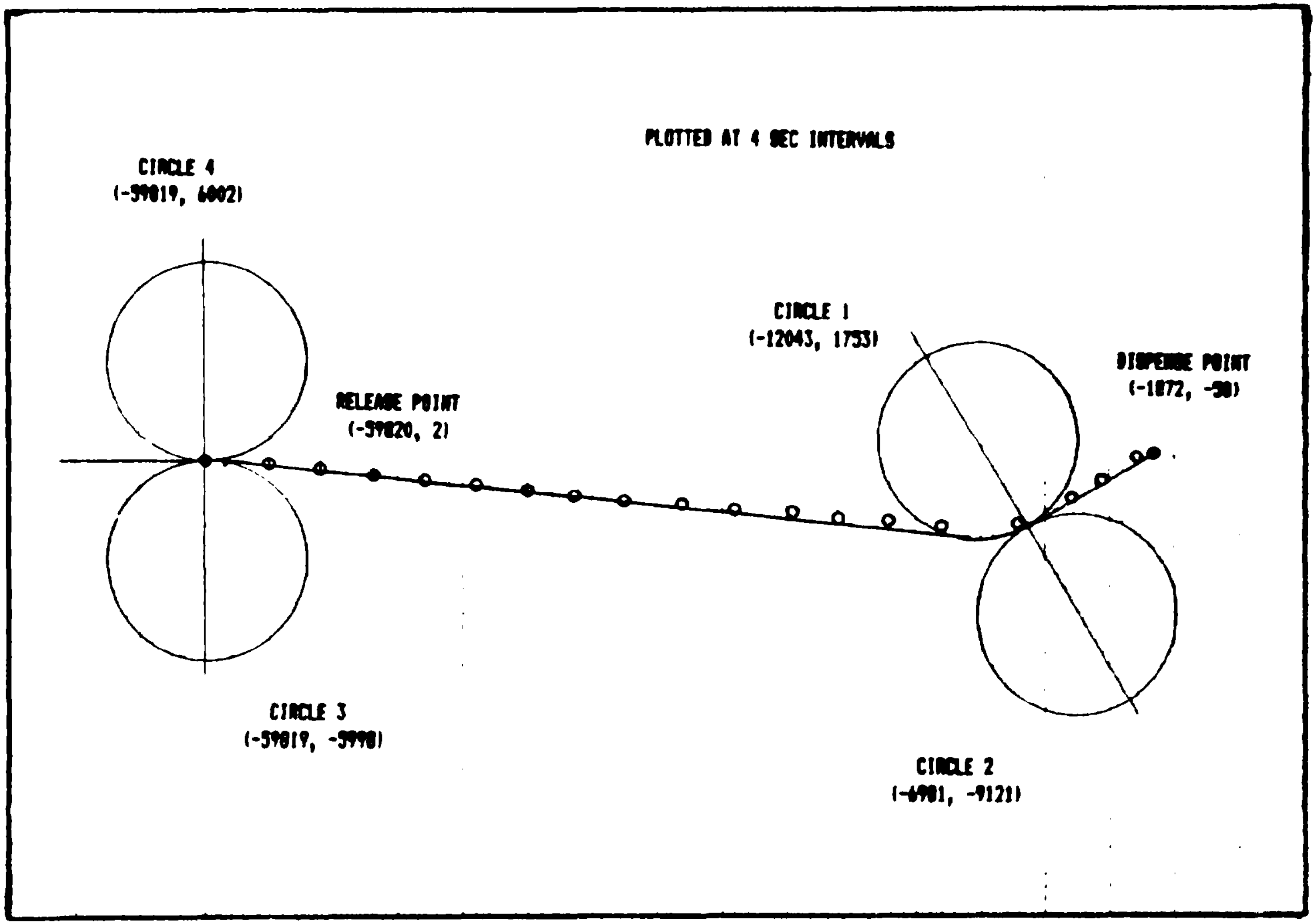


Figure 34. Weapon 11 Trajectory Plot

accomplished by collecting statistics on the activities representing the duration of the engagement and associated confounding delay. The maximum utilization of the activity represents the maximum number of simultaneous engagements during an attack. Both systems were again shown to accurately model the correct number of fire control channels to engage the incoming targets.

The next step was to verify the modeling of the SAM kill probability. Well before validation was even considered, additional data was obtained from AFATL/ENYS that indicated the present method for calculating kill probabilities was too simple to accurately model the system. The engagement grids, explained in Section II, were then implemented in the model after verification of the first method had already been completed. The earlier version performed as it was intended, but it did not fully describe the interactions between the missiles and the targets.

Implementation difficulties with the new method centered on identifying the position of the target in the grid in order to select the coded value from the kill probability data matrix. An Applesoft Basic program was used to assist the development and verification of the grid logic. Again, graphics were used to display the engagement geometry to simplify the process. Using this and hand-plotted representations of the engagement, the logic was quickly developed and verified. Only after completion of this process was any work attempted on the main model. The logic was converted to Fortran and inserted into the model to replace the previous kill probability logic.

After completion of these two steps, the SAM engagement and kill logic was determined to accurately function as intended. The task of verifying the AAA logic remained to be accomplished before validation of the model could be attempted.

AAA. Verification of the AAA was also accomplished in a two-step process and, again, changes were necessary after development of a working model. The AAA systems were modeled quite similar to the early versions of the SAM logic with a probability of engaging a target calculated each second and a kill probability based on range from the threat. The iterative nature of model development was again apparent during this phase of the project.

Verification of the original AAA engagement logic was a direct by-product of the SAM verification because the logic was essentially identical. The model functioned exactly as it was intended; but while gathering data from FTD analysts for validation of the model, faults with the AAA logic were identified. This information resulted in complete revision of the engagement logic.

The new logic called for selection of an incoming target and firing on that target until it was killed or the ammunition was depleted. After development of the new logic, verification was accomplished by running a single attack with print statements showing the attribute number identifying the attacked entity. This verified the new logic by showing that all bursts from a AAA site were fired at the same target.

As with the SAM engagements, the kill probability was then verified. The probability of kill for both AAA sites is described by Figure 16 in Section II. Print statements were selected as the most convenient method to verify the kill probabilities. Based on range and altitude, the program values were displayed in the program output and compared with hand-calculated results.

Validation

Validation of a model that simulates the interactions between opposing forces in a combat situation is a difficult task. Because of the unpredictable nature of the interactions, a Monte Carlo simulation can only give projected averages for attrition and runway damage. Lacking historical data and the capability to run a series of real-life engagements, simulation results can only be compared to other models or expert opinion for validation.

Standoff weapon attrition is difficult to validate because there is no model to use to produce comparisons nor is there a concensus among the experts. Although many models are available to predict attrition rates for targets the size of aircraft, standoff weapon attrition is not well understood. For this reason, validation of the engagement logic centered on attrition of the aircraft during attacks with conventional tactics. Therefore, the main purpose of modeling the conventional tactics was validation.

Damage expectancy is determined with AAP. Since data from AAP is used widely throughout the Air Force, the DE values are valid for the assumptions and scenario modeled in this effort.

Interviews were conducted with FTD analysts to determine a range of attrition rates that would be expected with the different conventional tactics during the OCA mission modeled in the study. The values presented in Table XV are unclassified estimates of enemy capabilities against penetrating aircraft. Overall aircraft attrition for each tactic is presented along with the individual system capabilities.

Table XV

Expected Aircraft Attrition Rates

System Capabilities	
Current SAM	10 - 20%
Out-year SAM	30 - 40%
AAA	10 - 15%

Overall Mission Attrition	
Level	15 - 25%
LALD	20 - 30%
Toss	10 - 15%

The system capabilities in the table are for a non-maneuvering fighter-size aircraft penetrating at low altitude. Aircraft attrition during the delivery maneuvers is expected to cause variations in attrition but not beyond the range of values in the table.

Multiple replications of each tactic were run with five different entry points into the terminal area. Each tactic/entry point combination was run with a 120 degree egress turn following release of the weapons. Half the replications were run with a left turn and half were run with the egress turn to the right. This was done to force the aircraft to fly through different parts of the threat envelope and experience the entire range of Pk values represented in the engagement grids. The statistics collected for the attacks are listed in Table XVI.

Table XVI

Model Attrition Rates

		Threat Pk (Percent)			
Tactic	Entry Heading	SAM 1	SAM 2	AAA 1	AAA 2
Level	150	9.62	38.10	15.66	9.67
	120	15.09	35.78	10.65	11.72
	090	7.50	30.56	13.69	10.03
	060	13.46	32.00	12.63	10.96
	030	11.90	38.76	9.51	12.83
	Average	11.72	35.00	12.43	11.01
LALD	150	22.22	32.00	15.71	10.08
	120	25.00	36.63	12.08	11.16
	090	14.71	40.25	11.97	14.62
	060	10.14	29.21	16.49	16.68
	030	1.35	30.65	14.28	11.32
	Average	13.93	33.89	14.28	12.78
Toss	150	13.10	32.99	--	--
	120	15.38	37.94	--	--
	090	14.77	33.12	--	--
	060	28.43	35.45	--	--
	030	14.61	39.20	--	--
	Average	17.48	34.98	--	--

Pk values for the AAA threats are calculated for each engagement which consists of an average of 5.63 bursts. The values reflect an average over both egress directions for each tactic/heading combination.

These attrition rates show a wide variance in the individual threat kill probabilities caused by the attack heading. Therefore, an overall mission Pk for each attack was calculated to compare with the predicted values. Statistical analysis of the data resulted in the averages in Table XVII and showed that the treatment (tactic) does have an effect on the attrition rate. The averages also agree well with the attrition expected by the FTD analysts.

Table XVII

Overall Mission Attrition

	Expected	Results
Level	15 - 25%	22.53
LALD	20 - 30%	25.00
Toss	10 - 15%	14.72

Attrition rates for the standoff weapon delivery vary as a function of the release parameters of the weapon and do not serve to validate the model because there is no basis for comparison of weapon capabilities. Validation of the model is, therefore, based only on current tactics employing current conventional weapons. Analysis of the results for the standoff tactic are contained in the next section.

VI. Results

The objective of the research, performed in this study, has been to develop a methodology for comparing a new weapon system with current inventory munitions. The methodology required developing a simulation model that could evaluate aircraft attrition during delivery of both current munitions and the new "standoff" weapon. The modeling of current munition delivery was critical in validation of the model's performance. The model correctly simulated aircraft flight during conventional tactics and was validated against expected aircraft attrition rates. Therefore, the model was considered to adequately represent the interactions of the individual elements in the system.

For the standoff weapon delivery, the model is more scenario dependent than it is for conventional weapon delivery tactics. The logic uses lower probability of engagement values for the weapons than for the aircraft. Threat engagement doctrine is established by adjustment of these values to determine which targets are considered primary by the defenses. It would be possible to eliminate weapon attrition by setting the engagement probability at such a low level that threats would always launch against an attacking aircraft. The values currently in the model reflect expert estimates of threat system capabilities and firing doctrine. Application of realistic estimates for standoff engagements and the incorporation of the same logic used for conventional attacks extends validation of the model to the standoff tactic. With a valid model, it is then necessary to perform some excursions on the model with respect to the standoff weapon release conditions; heading and range.

This activity, exercising the model, should show the expected relationships in the attrition and DE values as the delivery range and heading are varied. If these relationships are other than what would be expected from an understanding of the system dynamics, further analysis of those variations is necessary. It is expected that the weapon DE and aircraft attrition values should decrease as the standoff weapon is released at greater distances from the aimpoints. Also, the weapon attrition is expected to increase as the release range increases.

Two hundred replications were performed at 20 different points within the release cone. The release points were at headings of 150, 120, 090, 060, and 030 at release ranges of 5, 10, 15, and 20 NM for each heading. In each case, an attack element of two aircraft released two standoff weapons each. Both weapons released from each aircraft were targeted against the same aimpoint with an attack angle of 30 degrees. After release, the aircraft began either a left or right 120 degree egress turn. The direction of turn was selected to turn in the shortest direction to a westerly heading.

The results of the aircraft attrition and standoff weapon DE are listed in Table XVIII and Table XIX. As expected, the general trend over the various attack headings showed aircraft attrition and weapon DE values decreasing as the release range increased, shown in the column averages.

Table XVIII

Aircraft Attrition - Standoff Tactic (%)

Release Heading	Release Range 5	10	15	20	Avg
150	12.7	2.3	0	0	3.8
120	11.2	4.5	0	0	3.9
090	10.5	7.8	2.5	0	5.2
060	11.7	6.8	2.0	0	4.7
030	9.3	6.5	1.0	0	4.0
Avg	11.1	5.6	1.1	0	

The magnitude of the variations in aircraft attrition is dependent on the individual threat envelopes. At a 5 NM release, the aircraft penetrates the AAA lethal envelopes which causes a large increase in attrition over the value at 10 NM. As the heading varies, the attrition is influenced primarily by Threat 2. The location of the out-year threat causes the aircraft to be in a higher Pk region of the envelope when it ingresses from the south west. Enemy doctrine, as modeled, calls for a launch based only on time within the maximum range and does not consider Pk when making the decision to engage a target. Aircraft attacking from the north west are, therefore, usually further from the threat at launch and in grid blocks with lower Pk values.

Another general trend is the higher aircraft attrition values for release headings at 090, shown in the row averages. The aircraft attacking from that heading must fly through the highest Pk values for both the SAM threats. As the attack heading changes in either direction, the effect of one of the SAM threats is lessened.

Aircraft attrition values are important only to identify any obvious deviations from what was expected. Development of a better understanding of the interaction of the threats with both aircraft and standoff weapons is a necessary objective of the research.

Table XIX

Weapon DE - Standoff Tactic

Release Heading	Release Range 5	10	15	20	Avg
150	.98	.94	.73	.43	.77
120	.99	.95	.77	.47	.80
090	.96	.90	.69	.39	.74
060	.98	.95	.77	.46	.79
030	.96	.89	.61	.39	.71
Avg	.97	.93	.71	.43	

The highest DE values are related to the headings of 060 and 120. DE is strongly influenced by the CEP of the weapon when it dispenses. CEP is, in turn, dependent on the off-boresight angle. The closer the release heading is to the attack angle, the smaller are the turns and; therefore, the lower the off-boresight and CEP. The increased DE at these two headings results from the release heading being aligned with the attack angle on the runway.

Table XX presents weapon attrition results. In the cases where two values are shown, the first value represents the total attrition rate for all weapons entering the terminal area. The second value is the attrition rate for weapons that were engaged by threats after release from the aircraft. Both these values are significant in the analysis of the results. Single values are shown for cases where no weapons were lost prior to release from the aircraft.

Table XX

Standoff Weapon Attrition (%)

Release Heading	Release Range 5	10	15	20	Avg
150	8.7/2.9	3.2/2.3	4.5	2.7	4.8/3.1
120	7.3/2.4	4.6/3.4	4.6	4.1	5.2/3.6
090	7.6/3.3	6.0/2.6	3.8	3.9	5.3/3.4
060	9.4/3.1	5.6/3.2	4.4	4.4	6.0/3.5
030	9.5/2.4	6.5/3.1	4.9	4.1	6.2/3.6
Avg	8.5/2.8	5.2/2.9	4.4	3.8	

Total weapon losses decrease as the range increases because destruction of the aircraft before weapon release becomes more significant as the aircraft penetrates further into the defenses. This is seen by the large difference in the two average values for 5 NM. Trends in weapon attrition after release are not as clear. Table XXI represents data reduced from the results of each of the 20 different attacks listed in Appendix J. The table depicts the attrition percentage for standoff weapon losses after release from the aircraft.

Table XXI
Standoff Weapon Attrition by Threat (%)

Release Heading	Range	Current SAM	Outyear SAM	AAA 1	AAA 2
150	5	0	0	0.9	1.1
	10	5.6	6.7	0.6	0.6
	15	2.6	5.1	1.5	1.1
	20	0	4.8	0.8	0.8
120	5	0	7.1	0.8	0.7
	10	7.1	7.7	1.2	0.7
	15	0	15.5	1.1	1.1
	20	2.6	15.4	1.0	0.7
090	5	0	0	1.1	1.1
	10	7.7	8.6	0.5	0.8
	15	5.4	21.1	0.6	0.5
	20	0	12.7	0.5	1.3
060	5	0	14.3	0.9	1.0
	10	0	20.7	1.0	0.8
	15	0	15.7	1.3	0.7
	20	5.4	12.5	0.8	1.2
030	5	0	0	0.8	0.8
	10	0	5.6	1.2	0.7
	15	0	10.5	1.5	1.4
	20	6.7	14.8	0.5	1.1

For the 5 and 10 NM release ranges, there is only enough time to get one missile shot at the weapon prior to dispense. Attrition at these shorter ranges is mainly from the AAA threats. As the release range increases, SAM kills become more of a factor. The only discrepancy appears to be between the values at 15 NM and 20 NM. This inverse relation, higher attrition at 15 NM, is due to SAM firings at weapons while they are in the higher Pk region. The SAM firings on the 20 NM weapon releases occur in the outer regions of the lethal range where lower Pk values exist. Modification of the SAM logic could adjust for a firing doctrine that calls for a minimum acceptable Pk. This could be achieved by delaying missile launch until the target is within a more lethal part of the envelope. This study assumes SAM launch decisions are made whenever a target is within the maximum range, regardless of the kill probability.

As expected, Threat 2 (outyear SAM) has the greatest capability for destroying the weapon. This threat is modeled as having a larger lethal range and improved radar system for detection of small low-flying targets. When the Pk was computed for the two SAM threats, Threat 2 showed a great improvement (11.4% compared to 2.3%) over the older Threat 1. Also depicted in Table XX are very similar attrition values from each of the AAA sites. Both are modeled with identical capabilities, but are located at different points on the airfield. Because the location separation is not a significant distance, the attrition values vary only slightly. A computation of the Pk per AAA burst showed .93% and .91% for AAA 1 and 2, respectively.

It is necessary to understand three factors that affect the standoff weapon. First, standoff weapons do not exit the area after dispense; therefore, each threat has less firing time against the standoff weapon than against aircraft. Second, weapons released at extreme headings, 030 or 150, may greatly reduce interactions with one or the other SAM. For example, the release heading of 030 allows the weapon flight to almost completely avoid any attrition by Threat 1. Finally, whenever the standoff weapon is released at large off-boresight angles, the maximum range is reduced. Any release beyond approximately 13 NM requires reference to the weapon footprint to determine if it will have sufficient velocity at dispense (31:11).

The results of exercising the model showed expected trends in attrition on the aircraft and standoff weapon. It depicted the expected improvement in DE for weapons released closer to the target and on headings near the attack angle. The unexpected kill probabilities for the weapon after launch at 15 NM versus 20 NM was explained by analysis of individual threat kill probabilities. The most obvious reason is the overriding effect of Threat 2 on the closer releases due to the higher Pk values at launch.

VII. Conclusions and Recommendations

As stated in the research objective, the thrust of this effort was the development of a methodology for comparing current conventional munitions with a standoff weapon in the OCA mission area. The resulting simulation program modeled, for the first time, the interactions of terminal defensive systems with standoff weapons released from up to 20 NM from the target. The DE of the standoff weapons is, therefore, not only a factor of the weapon's ability to crater the runway as it is for current munitions; it is also a factor of weapon survivability after release from the aircraft.

Conclusions

The relatively small-scale model uses aggregated values for attrition of the aircraft and standoff weapons. Kill probabilities are selected from an engagement grid that is dependent only on target altitude, location, and ECM status. There is no provision in the model to consider pilot awareness factor, SAM break, or other defensive maneuvers. By comparison of the model outputs with expert opinion from FTD analysts, it is concluded that this model accurately represents the expected attrition rates for current tactics employed in this mission area. Therefore, the aggregate model produces realistic results more timely than large-scale models that are currently used for attrition studies.

Although the results of this study are scenario dependent, the methodology developed is not limited to a single scenario. The model was designed, from the beginning, to allow for simple modification of input values to represent different threat locations, capabilities, and friendly tactics. As presently structured, the model is limited to the study of the interactions between four individual threat sites, two ingressing aircraft, and up to a total of four weapons released from each aircraft. The flexibility in defining threat characteristics and the validated engagement logic provides the capability to study a wide variety of scenarios.

Currently, however, comparisons of standoff weapon tactics and conventional tactics are limited. Estimates for conventional weapon capabilities against a specified target utilizing a specific tactic are classified. Because of this, the methodology only demonstrates the capability to look up weapon capabilities from a data matrix. The classified data needed for this matrix can be easily attained from other sources. Additionally, Soviet doctrine and defensive stem capabilities can only be estimated from unclassified sources and included as a generic threat capability. Attempts have been made to select reliable sources to make the model as close to reality as possible, but no claim is made regarding the accuracy of individual threat capabilities.

A further limitation is the absence of a standoff weapon. Early development efforts established only baseline capabilities of a standoff weapon which have been used throughout the study. Damage expectancy and attrition estimates for the standoff weapon are very dependent on the assumptions and interpretations of the data and information available on this "paper" weapon.

Despite the current limitations, the methodology is valid and flexible enough to allow inclusion of both classified data and more accurate estimates of standoff capabilities when necessary. Also, the small size of the model will permit rapid return of output results.

Recommendations

Further study of the system characteristics is recommended in three main areas. The first two areas concentrate on developing a better understanding of the standoff weapon while the third is concerned with application of the model developed to date.

1. The engagement characteristics of the standoff weapon used in this model were based on estimated differences between a fighter-size aircraft and a standoff weapon. Examination of the weapon radar cross-section, SAM/AAA system capabilities, and Soviet firing doctrine using a large-scale model can lead to the development of engagement grids specifically for the standoff weapon. This will increase the capability of the model to provide accurate comparisons of the weapons.

2. Weapon DE values were extracted from AAP using a number of assumptions and scenario limitations. Further analysis of the capability of the standoff weapon to damage a runway should include parametric variations on the assumptions. This is necessary to insure that the same closure criteria is used for all weapons and that closure probabilities are consistent.
3. The model has the capability to identify the optimum release conditions for a given scenario. Presently, this is done by running a selected set of release points. Modification of the model to include a search routine could automatically select each point to close in on the optimum point.

These recommendations are not meant to imply that all other work in this area has been accomplished. They merely identify those areas that restrict the accuracy and application of the model.

Appendix A: Variable Listings

1. Attributes

ATRIB	Application		Value
1	Wpn	Acft	VEHICLE NUMBER
2	Wpn	Acft	PROFILE (WPN)/TACTIC (ACFT)
3	Wpn	Acft	VELOCITY (FT/SEC)
4	Wpn	Acft	TURN STATUS (1/2-NO TURN/TURN)
5	Wpn	Acft	RANGE TO TARGET
6	Wpn	Acft	X-COORD
7	Wpn	Acft	Y-COORD
8	Wpn	Acft	HEADING (RADIANS)
9	Wpn	Acft	TURN NUMBER (WPN)/LALD TIMING (ACFT)
10	Wpn	Acft	LAUNCH TIME
11	Wpn	Acft	TIME IN THREAT RING 1
12	Wpn	Acft	TIME IN THREAT RING 2
12	Wpn	Acft	TIME IN THREAT RING 3
14	Wpn	Acft	TIME IN THREAT RING 4
15	Wpn	-	DIRECTION OF FIRST TURN (-1/1 - L/R)
16	Wpn	-	DIRECTION OF SECOND TURN
17	Wpn	-	ROLLOUT HDG, FIRST TURN (RADIANS)
18	Wpn	-	ROLLOUT HDG, SECOND TURN (RADIANS)
19	Wpn	Acft	CURRENT HEADING (DEGREES TRUE)
20	Wpn	Acft	RELEASE HEADING (DEGREES TRUE)
21	Wpn	Acft	DISP HDG (WPN)/EGRESS TURN (ACFT)
22	Wpn	Acft	DISP RANGE (WPN)/20 NM CHECK (ACFT)

23	Wpn	-	DISPENSE X-COORD
24	Wpn	-	DISPENSE Y-COORD
25	Wpn	-	CENTER X, FIRST
26	Wpn	-	CENTER Y, FIRST
27	Wpn	-	CENTER X, SECOND
28	Wpn	-	CENTER Y, SECOND
29	Wpn	Acft	TARGET X
30	Wpn	Acft	TARGET Y
33	Wpn	Acft	STAND-OFF RANGE
34	Wpn	Acft	RELEASE X
35	Wpn	Acft	RELEASE Y
36	Wpn	Acft	STATUS (0/1 - DEAD/ALIVE)
37	-	Acft	RELEASE STATUS
38	-	Acft	BEARING AT ENTRY
39	-	Acft	EGRESS HEADING CHANGE
40	-	Acft	DIRECTION OF EGRESS TURN
41	Wpn	Acft	TIME OF FLIGHT
42	Wpn	Acft	ALTITUDE
43	Wpn	-	MOTOR TIMING
44	Wpn	Acft	PITCH ATTITUDE
45	Wpn	-	PRINT INTERVAL
51	Wpn	Acft	ATTACK STATUS, THREAT 1
52	Wpn	Acft	ATTACK STATUS, THREAT 2
53	Wpn	Acft	ATTACK STATUS, THREAT 3
54	Wpn	Acft	ATTACK STATUS, THREAT 4

2. Global Variables

XX	Value	
1	BOMB COUNTER - AIRCRAFT 1	
2	BOMB COUNTER - AIRCRAFT 2	
3	THREAT 1	X-COORD
4		Y-COORD
5		LETHAL RANGE
6		ENGAGEMENT INTERVAL
7	THREAT 2	X-COORD
8		Y-COORD
9		LETHAL RANGE
10		ENGAGEMENT INTERVAL
11	THREAT 3	X-COORD
12		Y-COORD
13		LETHAL RANGE
14		SELECTED TARGET
15	THREAT 4	X-COORD
16		Y-COORD
17		LETHAL RANGE
18		SELECTED TARGET
19	TURN RADIUS	
20	THREAT 2 ENGAGEMENTS	
21	THREAT STATUS, SITE 1	
22	THREAT STATUS, SITE 2	
23	THREAT STATUS, SITE 3	
24	THREAT STATUS, SITE 4	

25	NUMBER OF MISSILES, THREAT 1
26	NUMBER OF MISSILES, THREAT 2
30	PROB CLOSURE
31	REPLICATIONS/VEHICLES
32	AIRCRAFT KILLS
33	AIRCRAFT DESTROYED
34	AIRCRAFT CREATED
35	TACTIC
36	WEAPONS PER AIRCRAFT
37	TOTAL ENTITIES EXPECTED
38	ENTITIES PER REPLICATION
39	STANDOFF WEAPONS NOT LAUNCHED
40	PATTERN LENGTH
41	WEAPON TYPE
42	ATTACK ANGLE
45	TOTAL WEAPON FLIGHTTIME
46	DISPENSING WEAPONS
47	TOTAL WEAPON TURN
55	THREAT 1 AIRCRAFT NO LAUNCH PROB
56	THREAT 1 WEAPON NO LAUNCH PROB
57	THREAT 2 AIRCRAFT NO LAUNCH PROB
58	THREAT 2 WEAPON NO LAUNCH PROB
60	THREAT 3/4 NO FIRE PROB
61	THREAT 1 PK REDUCTION FOR WEAPONS
62	THREAT 2 PK REDUCTION FOR WEAPONS
63	THREAT 3/4 PK REDUCTION FOR WEAPONS
65	PROB KILL PER AAA BURST

Appendix B: SLAM Network Code

```
GEN,DCOULTER DFRY,THESIS NETWORK,1/20/86,1,N,N,Y,N,Y,72;
LIMITS,1,60,40;
ARRAY(1,3)/11.0,12.0,13.0;          CUT PROBABILITY-GP1
ARRAY(2,3)/21.0,22.0,23.0;          CUT PROBABILITY-GP2
ARRAY(3,3)/31.0,32.0,33.0;          CUT PROBABILITY-GP2MOD
ARRAY(4,3)/41.0,42.0,43.0;          CUT PROBABILITY-RP1
;
INTLC,XX(31)=200;                   REPLICATIONS
;
INTLC,XX(55)=.80,XX(56)=.95,
      XX(57)=.70,XX(58)=.90,
      XX(61)=4.0,XX(62)=4.0;        SAM ENGAGEMENT PARAMETERS
;
INTLC,XX(65)=.03,XX(63)=3.0;        AAA ENGAGEMENT PARAMETERS
INTLC,XX(42)=30.,XX(40)=500;         DISPENSE PARAMETERS
INTLC,XX(41)=1.0,XX(36)=2.0;         WEAPON PARAMETERS
;
INTLC,XX(35)=4;    DELIVERY TACTIC
;                       1 - LEVEL
;                       2 - TOSS
;                       3 - LALD
;                       4 - STANDOFF
NETWORK;
;
;MODULE 1 BEGIN =============== ENTITY COUNT ==============
      CREATE,1,0,,1,1;
         ACT,,XX(35) .GT. 3,TT;
         ACT,,XX(35) .LT. 4,T2;
TT    ASSIGN, XX(38)=2+2*XX(36),1;
      TERMINATE;
T2    ASSIGN, XX(38)=2,1;
      TERMINATE;
;MODULE 1 END ================= ENTITY COUNT ==============
;
;MODULE 2 BEGIN ==== THREAT/REPLICATION INITIALIZATION =====
      CREATE,500,0,10,200,1;
SPEED ASSIGN,ATRIB(3)=885,
             ATRIB(4)=1,
             ATRIB(36)=1,
             ATRIB(37)=XX(36),
             ATRIB(45)=-5;
      ASSIGN,XX(1)=0,XX(2)=0;                   AC BOMB COUNTERS
SAM   ASSIGN,XX(3)=-4000,XX(4)=3000,
            XX(5)=81000,XX(6)=17,
            XX(7)=-8000,XX(8)=-6000,
            XX(9)=108000,XX(10)=17;             SAM 1 & 2
AAA   ASSIGN,XX(11)=-2000,XX(12)=-1000,
            XX(13)=9807,XX(14)=0,
            XX(15)=500,XX(16)=500,
```

```
          XX(17)=9807,XX(18)=0;                  AAA 1 & 2
TURN   ASSIGN,XX(19)=6000;                       TURN RADIUS
AMMO   ASSIGN,XX(25)=6,XX(26)=12,
          XX(27)=6,XX(28)=6;                     SAM & AAA AMMO
IDLE   ASSIGN,XX(21)=1,XX(22)=1,
           XX(23)=1,XX(24)=1,2;                  THREATS AVAIL
         ACT/1,,,AC1;                            AIRCRAFT 1
         ACT/2,,,AC2;                            AIRCRAFT 2
;MODULE 2 END ====== THREAT/REPLICATION INITIALIZATION =====
;
;MODULE 3 BEGIN ======== AIRCRAFT INITIALIZATION ==========
AC1    ASSIGN,ATRIB(1)=1;                AIRCRAFT 1
        ACT,,XX(35) .EQ. 4,STD1;             *********************
        ACT,,XX(35) .EQ. 1,LVL1;             * AIRCRAFT DELIVERY *
        ACT,,XX(35) .EQ. 2,TOS1;             *       TACTIC      *
        ACT,,XX(35) .EQ. 3,LAL1;             *********************
AC2    ASSIGN,ATRIB(1)=2;                AIRCRAFT 2
        ACT,,XX(35) .EQ. 4,STD2;             *********************
        ACT,,XX(35) .EQ. 1,LVL2;             * AIRCRAFT DELIVERY *
        ACT,,XX(35) .EQ. 2,TOS2;             *       TACTIC      *
        ACT,,XX(35) .EQ. 3,LAL2;             *********************
;
;      ------------------- AIRCRAFT 1 --------------------
;                          **  STANDOFF  **
STD1   ASSIGN,ATRIB(2)=4;
       ASSIGN,ATRIB(20)=100;                 RELEASE HEADING
       ASSIGN,ATRIB(33)=60000;               RELEASE RANGE
       ASSIGN,ATRIB(38)=90;                  BEARING AT ENTRY
       ASSIGN,ATRIB(39)=120;                 DELTA HDG (EGRESS)
       ASSIGN,ATRIB(40)=1;                   DIR OF EGRESS TURN
       ASSIGN,ATRIB(42)=200;                 INGRESS ALTITUDE
       ASSIGN,ATRIB(19)=ATRIB(20),1;
         ACT,,,IP;
;                            **  LEVEL   **
LVL1   ASSIGN,ATRIB(2)=1;
       ASSIGN,ATRIB(33)=6000;                RELEASE RANGE
       ASSIGN,ATRIB(38)=90;                  BEARING AT ENTRY
       ASSIGN,ATRIB(39)=120;                 DELTA HDG (EGRESS)
       ASSIGN,ATRIB(40)=1;                   DIR OF EGRESS TURN
       ASSIGN,ATRIB(42)=200;                 INGRESS ALTITUDE
       ASSIGN,ATRIB(30)=-1361,
             ATRIB(31)=119,1;                WEAPON AIMPOINT
         ACT,,,IP;
;                             **  TOSS   **
TOS1   ASSIGN,ATRIB(2)=2;
       ASSIGN,ATRIB(33)=23000;               RELEASE RANGE
       ASSIGN,ATRIB(38)=90;                  BEARING AT ENTRY
       ASSIGN,ATRIB(39)=120;                 DELTA HDG (EGRESS)
       ASSIGN,ATRIB(40)=1;                   DIR OF EGRESS TURN
       ASSIGN,ATRIB(42)=200;                 INGRESS ALTITUDE
       ASSIGN,ATRIB(30)=-1361,
             ATRIB(31)=119,1;                WEAPON AIMPOINT
         ACT,,,IP;
```

```
;                              **  LALD   **
LAL1   ASSIGN,ATRIB(2)=3;
       ASSIGN,ATRIB(33)=5900;             RELEASE RANGE
       ASSIGN,ATRIB(38)=90;               BEARING AT ENTRY
       ASSIGN,ATRIB(39)=120;              DELTA HDG (EGRESS)
       ASSIGN,ATRIB(40)=-1;               DIR OF EGRESS TURN
       ASSIGN,ATRIB(42)=200;              INGRESS ALTITUDE
       ASSIGN,ATRIB(30)=-1361,
              ATRIB(31)=119,1;            WEAPON AIMPOINT
         ACT,,,IP;
;      -------------------- AIRCRAFT 2 ----------------------
;                           **  STANDOFF  **
STD2   ASSIGN,ATRIB(2)=4;
       ASSIGN,ATRIB(20)=100;              RELEASE HEADING
       ASSIGN,ATRIB(33)=60000;            RELEASE RANGE
       ASSIGN,ATRIB(38)=87.2;             BEARING AT ENTRY
       ASSIGN,ATRIB(39)=120;              DELTA HDG (EGRESS)
       ASSIGN,ATRIB(40)=1;                DIR OF EGRESS TURN
       ASSIGN,ATRIB(42)=200;              INGRESS ALTITUDE
       ASSIGN,ATRIB(19)=ATRIB(20),1;
         ACT,,,IP;
;                             **  LEVEL   **
LVL2   ASSIGN,ATRIB(2)=1;
       ASSIGN,ATRIB(33)=6000;             RELEASE RANGE
       ASSIGN,ATRIB(38)=87.2;             BEARING AT ENTRY
       ASSIGN,ATRIB(39)=120;              DELTA HDG (EGRESS)
       ASSIGN,ATRIB(40)=1;                DIR OF EGRESS TURN
       ASSIGN,ATRIB(42)=200;              INGRESS ALTITUDE
       ASSIGN,ATRIB(30)=1361,
              ATRIB(31)=-119,1;           WEAPON AIMPOINT
         ACT,,,IP;
;                              **  TOSS   **
TOS2   ASSIGN,ATRIB(2)=2;
       ASSIGN,ATRIB(33)=23000;            RELEASE RANGE
       ASSIGN,ATRIB(38)=87.2;             BEARING AT ENTRY
       ASSIGN,ATRIB(39)=120;              DELTA HDG (EGRESS)
       ASSIGN,ATRIB(40)=1;                DIR OF EGRESS TURN
       ASSIGN,ATRIB(42)=200;              INGRESS ALTITUDE
       ASSIGN,ATRIB(30)=1361,
              ATRIB(31)=-119,1;           WEAPON AIMPOINT
         ACT,,,IP;
;                              **  LALD   **
LAL2   ASSIGN,ATRIB(2)=3;
       ASSIGN,ATRIB(33)=5900;             RELEASE RANGE
       ASSIGN,ATRIB(38)=87.2;             BEARING AT ENTRY
       ASSIGN,ATRIB(39)=120;              DELTA HDG (EGRESS)
       ASSIGN,ATRIB(40)=-1;               DIR OF EGRESS TURN
       ASSIGN,ATRIB(42)=200;              INGRESS ALTITUDE
       ASSIGN,ATRIB(30)=1361,
              ATRIB(31)=-119,1;           WEAPON AIMPOINT
         ACT,,,IP;
;MODULE 3 END ========== AIRCRAFT INITIALIZATION ==========
;
```

```
;MODULE 4 BEGIN ========= WEAPON INITIALIZATION ===========
WPN    ASSIGN, ATRIB(4)=2,ATRIB(9)=1,ATRIB(10)=TNOW;
         ACT/15;                          WPNS RELEASE
       ASSIGN,ATRIB(11)=0,ATRIB(12)=0,
              ATRIB(13)=0,ATRIB(14)=0,1;
         ACT,,ATRIB(2) .LT. 4,KTER;
         ACT,,ATRIB(1) .EQ. 1,WPN1;
         ACT,,ATRIB(1) .EQ. 2,WPN2;
KTER   TERM;
WPN1   ASSIGN,ATRIB(1)=10+XX(1),1;
         ACT/11,,ATRIB(1) .EQ. 11, WP11;    AC 1/WPN 1
         ACT/12,,ATRIB(1) .EQ. 12, WP12;    AC 1/WPN 2
         ACT/13,,ATRIB(1) .EQ. 13, WP13;    AC 1/WPN 3
         ACT/14,,ATRIB(1) .EQ. 14, WP14;    AC 1/WPN 4
WPN2   ASSIGN,ATRIB(1)=20+XX(2),1;
         ACT/21,,ATRIB(1) .EQ. 21, WP21;    AC 2/WPN 1
         ACT/22,,ATRIB(1) .EQ. 22, WP22;    AC 2/WPN 2
         ACT/23,,ATRIB(1) .EQ. 23, WP23;    AC 2/WPN 3
         ACT/24,,ATRIB(1) .EQ. 24, WP24;    AC 2/WPN 4
;      ------- STANDOFF WEAPON PARAMETER ASSIGNMENTS -------
;                  -----    AC 1 WEAPONS    -----
WP11   ASSIGN, ATRIB(21)=65,ATRIB(45)=TNOW,1;    DISPENSE HDG
       ASSIGN, ATRIB(22)=9000,1;                 ROLLOUT RANGE
       ASSIGN, ATRIB(30)=-1361,ATRIB(31)=119,1;  X,Y AIMPOINT
         ACT,,,PARA;
WP12   ASSIGN, ATRIB(21)=65,ATRIB(45)=TNOW-1,1;  DISPENSE HDG
       ASSIGN, ATRIB(22)=9000,1;                 ROLLOUT RANGE
       ASSIGN, ATRIB(30)=-1361,ATRIB(31)=119,1;  X,Y AIMPOINT
         ACT,,,PARA;
WP13   ASSIGN, ATRIB(21)=65,ATRIB(45)=TNOW-2,1;  DISPENSE HDG
       ASSIGN, ATRIB(22)=9000,1;                 ROLLOUT RANGE
       ASSIGN, ATRIB(30)=-1361,ATRIB(31)=119,1;  X,Y AIMPOINT
         ACT,,,PARA;
WP14   ASSIGN, ATRIB(21)=65,ATRIB(45)=TNOW-3,1;  DISPENSE HDG
       ASSIGN, ATRIB(22)=9000,1;                 ROLLOUT RANGE
       ASSIGN, ATRIB(30)=-1361,ATRIB(31)=119,1;  X,Y AIMPOINT
         ACT,,,PARA;
;                  -----    AC 2 WEAPONS    -----
WP21   ASSIGN, ATRIB(21)=65,ATRIB(45)=TNOW,1;    DISPENSE HDG
       ASSIGN, ATRIB(22)=9000,1;                 ROLLOUT RANGE
       ASSIGN, ATRIB(30)=1361,ATRIB(31)=-119,1;  X,Y AIMPOINT
         ACT,,,PARA;
WP22   ASSIGN, ATRIB(21)=65,ATRIB(45)=TNOW-1,1;  DISPENSE HDG
       ASSIGN, ATRIB(22)=9000,1;                 ROLLOUT RANGE
       ASSIGN, ATRIB(30)=1361,ATRIB(31)=-119,1;  X,Y AIMPOINT
         ACT,,,PARA;
WP23   ASSIGN, ATRIB(21)=65,ATRIB(45)=TNOW-2,1;  DISPENSE HDG
       ASSIGN, ATRIB(22)=9000,1;                 ROLLOUT RANGE
       ASSIGN, ATRIB(30)=1361,ATRIB(31)=-119,1;  X,Y AIMPOINT
         ACT,,,PARA;
WP24   ASSIGN, ATRIB(21)=65,ATRIB(45)=TNOW-3,1;  DISPENSE HDG
       ASSIGN, ATRIB(22)=9000,1;                 ROLLOUT RANGE
       ASSIGN, ATRIB(30)=1361,ATRIB(31)=-119,1;  X,Y AIMPOINT
```

```
         ACT,,,PARA;
;MODULE 4 END ========== WEAPON INITIALIZATION ============
;
;MODULE 5 BEGIN ========= AIRCRAFT TRAJECTORY =============
IP     EVENT,4;
       EVENT,9;
         ACT,1;
FLY    EVENT,6,1;
         ACT,,ATRIB(37).LT.0.5 .AND. ATRIB(3) .LT. 1000,WARP;
         ACT,,,MOD7;
WARP   ASSIGN,ATRIB(3)=ATRIB(3)+8;
         ACT,,,MOD7;
;                           [BRANCH TO THREAT ASSESSMENT]
ACO    EVENT,9,1;
         ACT,,ATRIB(5) .LE. ATRIB(33),LAUN;
         ACT,,ATRIB(5) .GT. ATRIB(33);
       GOON,1;
         ACT,1,ATRIB(22) .LE. 120000,FLY;
         ACT;
       ASSIGN,ATRIB(45)=0;
       EVENT,9;
         ACT,,,TERM;
LAUN   ASSIGN,II=ATRIB(1),1;
         ACT,1,XX(II) .GE. XX(36),FLY;
         ACT,,ATRIB(2) .LT. 4,CONV;
         ACT,,,REL;
CONV   ASSIGN, XX(II)=3,1;
REL    ASSIGN,ATRIB(34)=ATRIB(6),ATRIB(35)=ATRIB(7),1;
       ASSIGN,ATRIB(29)=TNOW,XX(II)=XX(II)+1,
              ATRIB(37)=ATRIB(37)-1,2;
         ACT,1,XX(II) .LT. XX(36),FLY;
         ACT,,,WPN;
         ACT,,,EGR;
EGR    ASSIGN,ATRIB(4)=2,ATRIB(37)=0,1;
       EVENT,7;                          ** WEAPON RELEASE **
         ACT,1,,FLY;
;MODULE 5 END ========== AIRCRAFT TRAJECTORY =============
;
;MODULE 6 BEGIN ========= WEAPON TRAJECTORY ===============
PARA   EVENT,1;                     DETERMINE FLIGHT PROFILE
       EVENT,5;                     PRINT ATTRIBUTES
       EVENT,9;                     PRINT LOCATION
FLYON  GOON,1;
         ACT,,ATRIB(41) .GT. 90,SLO;
         ACT,,ATRIB(41) .LE. 90,CONST;
SLO    ASSIGN, ATRIB(3)=ATRIB(3)-5*ATRIB(4),1;
         ACT,1,,NEW;
CONST  ASSIGN, ATRIB(3)=ATRIB(3)-5*ATRIB(4),1;
       ASSIGN, ATRIB(43)=ATRIB(43)+1,1;
         ACT,,ATRIB(43) .GE. 30,BOOST;
         ACT.1,,NEW;
BOOST  ASSIGN, ATRIB(3)=885;
       ASSIGN, ATRIB(43)=0,1;
```

```
         ACT,1;
NEW     EVENT,2;                                UPDATE LOCATION
         ACT,,,MOD7;
;                          [BRANCH TO THREAT ASSESSMENT]
WCO     EVENT,9,1;
         ACT,,ATRIB(5) .LE. 1200,DISP;
         ACT,,,FLYON;
DISP    GOON;
        EVENT,3;                                DISPENSE EVENT
         ACT,,,TERM;
;MODULE 6 END ============ WEAPON TRAJECTORY ==============
;
;MODULE 7 BEGIN ========== THREAT ASSESSMENT ==============
MOD7    EVENT,10,1;
         ACT,,ATRIB(51) .EQ. 0,A2;
         ACT;
;       ---------- THREAT 1 ----------
        COLCT(1),ATRIB(1),THR 1 LAUNCH,24,1.00,1.0,1;
        EVENT,11,1;
         ACT,,ATRIB(1) .LT. 10,APK1;
         ACT,,ATRIB(1) .GT. 10,WPK1;
APK1    COLCT(3),1-ATRIB(36),THR 1 ACFT PK;
         ACT,,,SPL1;
WPK1    COLCT(4),1-ATRIB(36),THR 1 WEAP PK;
         ACT,,,SPL1;
SPL1    GOON,2;
         ACT,,,A2;
         ACT/31,UNFRM(25,35,1),XX(25) .GT. 0,THR1;THR1 ENGAGE
A2      GOON,1;
         ACT,,ATRIB(36) .LT. 0.5,A15;
         ACT,,ATRIB(52) .EQ. 0,A3;
         ACT;
;       ---------- THREAT 2 ----------
        COLCT(5),ATRIB(1),THR 2 LAUNCH,24,1.00,1.0,1;
        EVENT,12,1;
         ACT,,ATRIB(1) .LT. 10,APK2;
         ACT,,ATRIB(1) .GT. 10,WPK2;
APK2    COLCT(7),1-ATRIB(36),THR 2 ACFT PK;
         ACT,,,SPL2;
WPK2    COLCT(8),1-ATRIB(36),THR 2 WEAP PK;
         ACT,,,SPL2;
SPL2    GOON,2;
         ACT,,,A3;
         ACT/32,UNFRM(25,35,2),XX(26) .GT. 0,THR2;THR2 ENGAGE
A3      GOON,1;
         ACT,,ATRIB(36) .LT. 0.5,A25;
         ACT,,ATRIB(53) .EQ. 0,SPL3;
         ACT;
;       ---------- THREAT 3 ----------
        COLCT(9),ATRIB(1),THR 3 BURSTS,24,1.00,1.0,1;
        EVENT,13,1;
         ACT,,ATRIB(1) .LT. 10,APK3;
         ACT,,ATRIB(1) .GT. 10,WPK3;
```

```
APK3  COLCT(11),1-ATRIB(36),THR 3 ACFT PK;
        ACT,,,SPL3;
WPK3  COLCT(12),1-ATRIB(36),THR 3 WEAP PK;
        ACT,,,SPL3;
SPL3  GOON,1;
        ACT,,ATRIB(36) .LT. 0.5,A35;
        ACT,,ATRIB(54) .EQ. 0,A5;
        ACT;
;     ---------- THREAT 4 ----------
      COLCT(13),ATRIB(1),THR 4 BURSTS,24,1.00,1.0,1;
      EVENT,14,1;
        ACT,,ATRIB(1) .LT. 10,APK4;
        ACT,,ATRIB(1) .GT. 10,WPK4;
APK4  COLCT(15),1-ATRIB(36),THR 4 ACFT PK;
        ACT,,,SPL4;
WPK4  COLCT(16),1-ATRIB(36),THR 4 WEAP PK;
        ACT,,,SPL4;
SPL4  GOON,1;
        ACT,,ATRIB(36) .LT. 0.5,A45;
        ACT,,,A5;
;     ------------ RESET THREAT AVAILABILITY --------
THR1  ASSIGN,XX(21)=1;
      TERM;
THR2  ASSIGN,XX(22)=1,XX(20)=XX(20)-1;
      TERM;
;     -- --------------- KILL TOTALS ----------------
A15   COLCT(2),ATRIB(1),THR 1 KILLS,25,1.0,1.0,1;
        ACT,,,STAT;
A25   COLCT(6),ATRIB(1),THR 2 KILLS,25,1.0,1.0,1;
        ACT,,,STAT;
A35   COLCT(10),ATRIB(1),THR 3 KILLS,25,1.0,1.0,1;
        ACT,,,STAT;
A45   COLCT(14),ATRIB(1),THR 4 KILLS,25,1.0,1.0,1;
        ACT,,,STAT;
;     ---------------------------------------------
;     ---------------- TARGET STATUS ----------------
STAT  GOON,1;
        ACT,,ATRIB(1) .GT. 10,A5;
        ACT;
      COLCT(18),ATRIB(37),PYLON STATUS,1.0,0.0,1.0,1;
        ACT,,XX(35) .LT. 4,A5;
        ACT;
      ASSIGN,XX(39)=XX(39)+ATRIB(37);     WEAPONS ON AIRCRAFT
A5    GOON,1;
        ACT/18,,ATRIB(36) .LT. 0.5, ATER; TOT DESTROY
        ACT,,ATRIB(1) .LT. 10,ACO;       RETURN TO AC FLIGHT
        ACT,,ATRIB(1) .GT. 10,WCO;       RETURN TO WPN FLIGHT
ATER  COLCT(17),ATRIB(1),TOTAL KILLS,24,1.0,1.0,1;
        ACT/19,,ATRIB(1) .LE. 10,TERM;    AC DESTROY
        ACT/20,,ATRIB(1) .GT. 10,TERM;    WPN DESTROY
;MODULE 7 END ============== THREAT ASSESSMENT ===========
;
;MODULE 8 BEGIN ========== TERMINATION PARAMETERS =========
```

```
TERM   COLCT(22),ATRIB(41),FLIGHT TIME;
       GOON,1;
         ACT/29,,ATRIB(1) .LT. 10,GO;      AIRCRAFT
         ACT,,,GO;
GO     GOON,1;
         ACT/30;                           TOTAL
EIGHT ASSIGN,XX(37)=XX(31)*XX(38)-XX(39),1;
       COLCT(23),XX(39),WEAPONS LOST;
STOP   GOON,1;
         ACT,,NNCNT(30) .LT. XX(37),DFRY;
         ACT,,XX(35) .LT. 4,EVE;
         ACT;
       ASSIGN,XX(45)=XX(45)/XX(46),
              XX(47)=XX(47)/XX(46),
              XX(33)=NNCNT(19),XX(34)=NNCNT(29);
EVE    EVENT,8,1;
       COLCT(19),XX(30),PROB CLOSURE;
       COLCT(20),NNCNT(19)/NNCNT(29),AIRCRAFT PK;
       COLCT(21),NNCNT(20)/NNCNT(15),WEAPON PK;
ELMO   TERM,1;
DFRY   TERM;
;MODULE 8 END ========== TERMINATION PARAMETERS ===========
;
       ENDNETWORK;
INIT,0,100000;
FIN;
```

Appendix C: Fortran Code

```
      PROGRAM THESIS FORTRAN
      DIMENSION NSET(10000)
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
     1MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE, S(100)
     2SSL(100),TNEXT,TNOW,XX(100)
      COMMON QSET(10000)
      EQUIVALENCE(NSET(1),QSET(1))
      NNSET=10000
      NCRDR=5
      NPRNT=6
      NTAPE=7
      NPLOT=2
      CALL SLAM
      STOP
      END
C
C     *********************** EVENT **********************
      SUBROUTINE EVENT(I)
C     ---------------------------------------------------
C      THIS SUBROUTINE CONTAINS FORTRAN EVENTS CALLED BY THE
C      SLAM NETWORK.
C
C           EVENT          FUNCTION                 LINE #
C           -----          --------                 ------
C             1      DETERMINE FLIGHT PROFILE         10
C             2      FLY WEAPON                       20
C             3      PRINT DISPENSE                   70
C             4      LOCATE ENTRY POINT               80
C             5      PRINT ATTRIBUTES  LAUNCH/KILL    90
C             6      FLY AIRCRAFT                    100
C             7      PRINT RELEASE                   110
C             8      CLOSURE PROBABILITY             120
C             9      PRINT WEAPON LOCATION           130
C            10      DETERMINE TIME IN THREAT        140
C            11      ENGAGEMENT SITE 1               150
C            12      ENGAGEMENT SITE 2               160
C            13      ENGAGEMENT SITE 3               170
C            14      ENGAGEMENT SITE 4               180
C     ---------------------------------------------------
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
     1MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),
     2SSL(100),TNEXT,TNOW,XX(100)
      COMMON/GRID/THREATA(19,6.2,2),THREATB(19,6,2,2)
      COMMON/ROLL/ITURN, RADIUS
      COMMON/LOCA/MISSX,MISSY,PKILL,RMAX,ALT,ECM,RINC
      REAL MISSX,MISSY
      INTEGER THREATA,THREATB,TRACK,ALT,ECM,
     1       RMAX,RINC,SHOTS3,SHOTS4
      GO TO (10,20,70,80,90,100,110,120,
```

```
     1         130,140,150,160,170,180),I

C    *********  EVENT(1)   DETERMINE FLIGHT PROFILE *********
10     ATRIB(23)=ATRIB(30)+ATRIB(22)*
     1          COS(-(ATRIB(21)/57.295)-1.5708)
       ATRIB(24)=ATRIB(31)+ATRIB(22)*
     1          SIN(-(ATRIB(21)/57.295)-1.5708)
       RADIUS=XX(19)
       CALL CIRCOORDS
       ITURN=NINT(ATRIB(2))
       CALL ROLLOUTS
       ATRIB(42)=200
       ATRIB(18)=1.5708-ATRIB(21)/57.295
       ATRIB(8)=1.5708-ATRIB(20)/57.295
       ATRIB(19)=ATRIB(20)
       ATRIB(5)=SQRT((ATRIB(6)-ATRIB(30))**2+
     1              (ATRIB(7)-ATRIB(31))**2)
       ATRIB(46)=ABS(ATRIB(20)-(90-57.3*ATRIB(17)))+
     1          ABS((90-57.3*ATRIB(17))-ATRIB(21))
       RETURN
C    *********************************************************
C
C    ***************   EVENT(2)   FLY WEAPON   ***************
20     IWHI=NINT(ATRIB(9))
       ATRIB(41)=TNOW-ATRIB(10)
       IF(ATRIB(41) .LE. 3.OR.ATRIB(5) .LT. 9000)ATRIB(44)=10
       IF(ATRIB(41) .GT. 3.AND.ATRIB(5) .GT. 9000)ATRIB(44)=0
       IF(ATRIB(5) .LT. 6000)ATRIB(44)=0
       ATRIB(42)=ATRIB(42)+ATRIB(3)*SIN(ATRIB(44)/57.3)
       RADIUS=XX(19)
       ISTAT=NINT(ATRIB(4))
       GO TO (30,40),ISTAT
C      ----------  WINGS LEVEL FLIGHT  ----------
30     ATRIB(6)=ATRIB(6)+ATRIB(3)*COS(ATRIB(8))
       ATRIB(7)=ATRIB(7)+ATRIB(3)*SIN(ATRIB(8))
       ATRIB(5)=SQRT((ATRIB(6)-ATRIB(30))**2
     1              +(ATRIB(7)-ATRIB(31))**2)
       GO TO (31,35),IWHI
31     DISTANCE=SQRT((ATRIB(6)-ATRIB(27))**2
     1              +(ATRIB(7)-ATRIB(28))**2)
       IF (DISTANCE .LE. RADIUS+200) THEN
          ATRIB(9)=2
          ATRIB(4)=2
       ENDIF
35     RETURN
C      ----------  TURNING FLIGHT  ----------
40     GO TO (50,60),IWHI
C      -----  FIRST TURN -----
50     DELTAH=ATRIB(3)/RADIUS*ATRIB(15)
       ATRIB(19)=ATRIB(19)+(DELTAH*57.295)
       ATRIB(8)=ATRIB(8)-DELTAH
       ATRIB(6)=ATRIB(25)-RADIUS*SIN(ATRIB(8))*ATRIB(15)
       ATRIB(7)=ATRIB(26)+RADIUS*COS(ATRIB(8))*ATRIB(15)
```

```
      ATRIB(5)=SQRT((ATRIB(6)-ATRIB(30))**2
     1              +(ATRIB(7)-ATRIB(31))**2)
      IF (ATRIB(15) .LT. 0) THEN
         IF (ATRIB(8) .GE. ATRIB(17)) THEN
            ATRIB(8)=ATRIB(17)
            ATRIB(19)=90-(ATRIB(17)*57.295)
            ATRIB(4)=1
         ENDIF
      ENDIF
      IF (ATRIB(15) .GT. 0) THEN
         IF (ATRIB(8) .LE. ATRIB(17)) THEN
            ATRIB(8)=ATRIB(17)
            ATRIB(19)=90-(ATRIB(17)*57.295)
            ATRIB(4)=1
         ENDIF
      ENDIF
      RETURN
C     -----  SECOND TURN  -----
60    DELTAH=ATRIB(3)/RADIUS*ATRIB(16)
      ATRIB(19)=ATRIB(19)+(DELTAH*57.295)
      ATRIB(8)=ATRIB(8)-DELTAH
      ATRIB(6)=ATRIB(27)-RADIUS*SIN(ATRIB(8))*ATRIB(16)
      ATRIB(7)=ATRIB(28)+RADIUS*COS(ATRIB(8))*ATRIB(16)
      ATRIB(5)=SQRT((ATRIB(6)-ATRIB(30))**2
     1              +(ATRIB(7)-ATRIB(31))**2)
      IF (ATRIB(16) .LT. 0) THEN
         IF (ATRIB(8) .GE. ATRIB(18)) THEN
            ATRIB(8)=ATRIB(18)
            ATRIB(19)=90-(ATRIB(18)*57.295)
            ATRIB(4)=1
         ENDIF
      ENDIF
      IF (ATRIB(16) .GT. 0) THEN
         IF (ATRIB(8) .LE. ATRIB(18)) THEN
            ATRIB(8)=ATRIB(18)
            ATRIB(19)=90-(ATRIB(18)*57.295)
            ATRIB(4)=1
         ENDIF
      ENDIF
      RETURN
C     ******************************************************
C
C     ***************  EVENT(3)   DISPENSE ****************
70    CONTINUE
C     PRINT*,'WEAPON ',NINT(ATRIB(1)),' AT DISPENSE.'
      XX(45)=XX(45)+ATRIB(41)
      XX(46)=XX(46)+1
      XX(47)=XX(47)+ATRIB(46)
      RETURN
C     ******************************************************
C
C     *********  EVENT(4)   LOCATE ENTRY POINT   ***********
80    ATRIB(6)=120000*COS(-(ATRIB(38)/57.295)-1.5708)
```

```
      ATRIB(7)=120000*SIN(-(ATRIB(38)/57.295)-1.5708)
      ATRIB(5)=SQRT((ATRIB(6)-ATRIB(30))**2
     1              +(ATRIB(7)-ATRIB(31))**2)
      IF (ATRIB(2) .LT. 3.5) THEN
        ATRIB(8)=ATAN((ATRIB(31)-ATRIB(7))/
     1                (ATRIB(30)-ATRIB(6)))
        ATRIB(19)=90-(ATRIB(8)*57.295)
      ENDIF
      SHOTS3=1
      SHOTS4=1
      IF (XX(35) .LT. 4)XX(46)=1
      RETURN
C     ******************************************************
C
C     ************  EVENT(5)   PRINT ATRIBUTES  *************
90    CONTINUE
C     WRITE(13,92)
C     WRITE(13,93)TNOW,TNOW-ATRIB(10),ATRIB(36)
C     WRITE(13,91)ATRIB(1),ATRIB(2),ATRIB(3),ATRIB(4),
C    1            ATRIB(5)
C     WRITE(13,91)ATRIB(6),ATRIB(7),ATRIB(8),ATRIB(9),
C    1            ATRIB(10)
C     WRITE(13,91)ATRIB(11),ATRIB(12),ATRIB(13),ATRIB(14),
C    1ATRIB(15)
C     WRITE(13,91)ATRIB(16),ATRIB(17),ATRIB(18),ATRIB(19),
C    1ATRIB(20)
C     WRITE(13,91)ATRIB(21),ATRIB(22),ATRIB(23),ATRIB(24),
C    1ATRIB(25)
C     WRITE(13,91)ATRIB(26),ATRIB(27),ATRIB(28),ATRIB(29),
C    1ATRIB(30)
C     WRITE(13,91)ATRIB(31),ATRIB(32),ATRIB(33),ATRIB(34),
C    1ATRIB(35)
C     WRITE(13,92)
91    FORMAT(9X,5F12.2)
92    FORMAT('          ----------------------------------------
     1-------------------------')
93    FORMAT(9X,3F12.2)
94    RETURN
C     ******************************************************
C
C     *************  EVENT(6)   FLY AIRCRAFT  ***************
100   ATRIB(8)=1.5708-ATRIB(19)/57.295
      ATRIB(41)=TNOW-ATRIB(10)
      ATRIB(6)=ATRIB(6)+ATRIB(3)*COS(ATRIB(8))*
     1         COS(ATRIB(44)/57.295)
      ATRIB(7)=ATRIB(7)+ATRIB(3)*SIN(ATRIB(8))*
     1         COS(ATRIB(44)/57.295)
      ATRIB(5)=SQRT((ATRIB(6)-ATRIB(30))**2+
     1         (ATRIB(7)-ATRIB(31))**2)
      ATRIB(22)=SQRT(ATRIB(6)**2+ATRIB(7)**2)
      IF (ATRIB(4) .GT. 1.5) THEN
        DELTAH=ATRIB(40)*57.3*(ATRIB(3)/XX(19))
        ATRIB(19)=ATRIB(19)+DELTAH
```

```
          ATRIB(21)=ATRIB(21)+DELTAH
          IF (ATRIB(19) .GT. 360) THEN
             ATRIB(19)=ATRIB(19)-360
          ENDIF
          IF (ATRIB(19) .LT. 0) THEN
             ATRIB(19)=ATRIB(19)+360
          ENDIF
       IF (ABS(ATRIB(21)) .GE. ATRIB(39)) THEN
          ATRIB(4)=1
          ENDIF
       ENDIF
       GO TO (101,102,103,104),NINT(ATRIB(2))
C      ----------  LEVEL TACTIC  ----------
101    IF (ATRIB(5) .LT. 10000 .AND. ATRIB(37) .GT. 0.5) THEN
          IF (ATRIB(42) .LT. 700) ATRIB(44)=10
          IF (ATRIB(42) .GE. 700) THEN
             ATRIB(44)=0
             ATRIB(42)=750
          ENDIF
       ENDIF
       IF (ATRIB(42) .GT. 200 .AND. ATRIB(37) .LT. 0.5) THEN
          ATRIB(44)=-10
       ENDIF
       GO TO 104
C      ----------  TOSS TACTIC  ----------
102    IF (ATRIB(5) .LT. 30000 .AND. ATRIB(37) .GT. 0.5) THEN
          IF (ATRIB(44) .LT. 45) THEN
             ATRIB(44)=ATRIB(44)+5
          ENDIF
       ENDIF
       IF (ATRIB(37) .LT.1 .AND. ATRIB(44) .GT. -20) THEN
          IF (ATRIB(42) .GT.700) THEN
             ATRIB(44)=ATRIB(44)-5
          ENDIF
       ENDIF
       IF (ATRIB(37) .LT. 1 .AND. ATRIB(42) .LE. 2500) THEN
          IF (ATRIB(44) .LT. 0) THEN
             ATRIB(44)=ATRIB(44)+5
          ENDIF
       ENDIF
       GO TO 104
C      ----------  LOW ANGLE TACTIC  ----------
103    IF (ATRIB(5) .GT. 21500) ATRIB(9)=TNOW
       IF (ATRIB(5) .LE. 21500 .AND. ATRIB(37) .GT. 0.5) THEN
          TIME=TNOW-ATRIB(9)
          IF(TIME .LE. 3)ATRIB(19)=ATRIB(19)+10
          IF(TIME .GE. 4 .AND. TIME .LE. 5)
     1       ATRIB(44)=ATRIB(44)+10
          IF(TIME .GE. 13 .AND. TIME .LE. 18) THEN
             ATRIB(44)=ATRIB(44)-4.4
             ATRIB(19)=ATRIB(19)-10
          ENDIF
          IF(TIME .GE. 19 .AND. TIME .LE. 20)THEN
```

```
            ATRIB(44)=ATRIB(44)-4.4
         ENDIF
         IF(TIME .EQ. 19) THEN
            ATRIB(8)=ATAN((ATRIB(31)-ATRIB(7))/
     1                    (ATRIB(30)-ATRIB(6)))
            ATRIB(19)=90-(ATRIB(8)*57.295)
         ENDIF
      ENDIF
      IF (ATRIB(37) .LT. 0.5 .AND. ATRIB(42) .GT. 300)THEN
         ATRIB(44)=-10
      ENDIF
      GO TO 104
C     ------  ALTITUDE CALCULATIONS FOR ALL TACTICS  -------
104   ATRIB(42)=ATRIB(42)+ATRIB(3)*SIN(ATRIB(44)/57.3)
      ATRIB(3)=ATRIB(3)-ATRIB(44)
      IF (ATRIB(42) .LT. 200) THEN
         ATRIB(44)=0
         ATRIB(42)=200
      ENDIF
      RETURN
C     ****************************************************
C
C     ***************  EVENT(7)   RELEASE  ****************
110   CONTINUE
C     PRINT*,'AIRCRAFT ',NINT(ATRIB(1)),' AT RELEASE.'
      RETURN
C     ****************************************************
C
C     **********  EVENT(8)   CLOSURE PROBABILITY  **********
120   GO TO (121,122,123,124),NINT(XX(35))
C     ----------  LEVEL  ----------
121   XX(30)=GETARY(NINT(XX(41)),1)
      RETURN
C     ----------  TOSS  ----------
122   XX(30)=GETARY(NINT(XX(41)),2)
      RETURN
C     ----------  LALD  ----------
123   XX(30)=GETARY(NINT(XX(41)),3)
      RETURN
C     ----------  STANDOFF  ----------
124   CEP=EXP(3.15183+0.015838*XX(45)+0.00353*XX(47))
      Z=-9.05947+(46.06775/ALOG(CEP))+
     1   (5.8725E-05*XX(42)**2)-(9.0149E-07*XX(40)**2)
      DE=EXP(Z)/(1+EXP(Z))
      DE=(XX(46)/(2*XX(36)*XX(31)))*DE
      DE=DE*2-DE**2
      IF(XX(36) .GT.3)DE=DE*2-DE**2
      XX(30)=DE
      RETURN
C     ****************************************************
C
C     *********  EVENT(9)   PRINT WEAPON LOCATION  *********
130   CONTINUE
```

```
      IF (TNOW-ATRIB(45) .GE. 1.0) THEN
C        WRITE(13,131)NINT(ATRIB(1)),NINT(ATRIB(41)),
C     1  NINT(ATRIB(11)),NINT(ATRIB(12)),NINT(ATRIB(13)),
C     2  NINT(ATRIB(14)),NINT(ATRIB(6)),NINT(ATRIB(7)),
C     3  NINT(ATRIB(3)),NINT(ATRIB(19)),NINT(ATRIB(44)),
C     4  NINT(ATRIB(42)),NINT(ATRIB(5))
         ATRIB(45)=TNOW
      ENDIF
131   FORMAT(9X,I2,5I4,2I8,I5,2I4,I5,I7)
132   RETURN
C     ***********************************************************
C
C     ************  EVENT(10)  TIME IN THREAT  *************
140   CONTINUE
C     -------------  THREAT 1  -------------
      RNG1=SQRT((ATRIB(6)-XX(3))**2+(ATRIB(7)-XX(4))**2)
      RNGE1=XX(5)+TRIAG(-8100.0,0.0,8100.0,1)
      IF(ATRIB(42) .LE. 500) THEN
         RNGE1=54000+TRIAG(-5400.0,0.0,5400.0,1)
      ENDIF
      IF (RNG1 .LE. RNGE1) THEN
         ATRIB(11)=ATRIB(11)+1
      ELSE
         ATRIB(11)=0
      ENDIF
      ATRIB(51)=0
      IF (ATRIB(11) .GT. 5 .AND. XX(21) .GT.0) THEN
         PROBL=UNFRM(0.0,1.0,1)
         SAFEA=XX(55)**(1/XX(6))
         SAFEW=XX(56)**(1/XX(6))
         IF (ATRIB(42) .LT. 500) PROBL=PROBL - (2/ATRIB(42))
         IF(PROBL.GE. SAFEA.AND.ATRIB(1) .LT. 10)ATRIB(51)=1
         IF(PROBL.GE. SAFEW.AND.ATRIB(1) .GT. 10)ATRIB(51)=1
         IF (ATRIB(51) .EQ. 1)XX(21)=0
         ATRIB(11)=0
      ENDIF
C     -------------  THREAT 2  -------------
      RNG2= SQRT((ATRIB(6)-XX(7))**2+(ATRIB(7)-XX(8))**2)
      RNGE2=XX(9)+TRIAG(-10800.0,0.0,10800.0,2)
      IF (ATRIB(42) .LE. 1000)RNGE2=96000+
     1                              TRIAG(-9600.0,0.0,9600.0,2)
      IF (RNG2 .GE. 13389 .AND. RNG2 .LE. RNGE2) THEN
         ATRIB(12)=ATRIB(12)+1
      ELSE
         ATRIB(12)=0
      ENDIF
      ATRIB(52)=0
      IF (ATRIB(12) .GT. 5 .AND. XX(22) .GT. 0) THEN
         PROBL=UNFRM(0.0,1.0,1)
         SAFEA=XX(57)**(1/XX(10))
         SAFEW=XX(58)**(1/XX(10))
         IF(ATRIB(42) .LT. 500) PROBL=PROBL - (2/ATRIB(42))
         IF(PROBL.GE. SAFEA.AND.ATRIB(1) .LT. 10)ATRIB(52)=1
```

```
      IF(PROBL.GE. SAFEW.AND.ATRIB(1) .GT. 10)ATRIB(52)=1
      IF (ATRIB(52) .EQ. 1) THEN
         XX(20)=XX(20)+1
         IF (XX(20) .GE. 4 ) XX(22)=0
      ENDIF
      ATRIB(12)=0
   ENDIF
C  ------------- THREAT 3 -------------
   RNG3= SQRT((ATRIB(6)-XX(11))**2+(ATRIB(7)-XX(12))**2)
   RNGE3=XX(13)-UNFRM(0.0,980.0,3)
   IF (RNG3 .LE. RNGE3) THEN
      ATRIB(13)=ATRIB(13)+1
      IF (XX(14) .LT. 1.0)THEN
         PICKIT=UNFRM(0.0,1.0,3)
         IF (PICKIT .LT. (1/XX(38)))XX(14)=ATRIB(1)
         IF (XX(14) .EQ. XX(18))XX(14)=0
      ENDIF
   ELSE
      ATRIB(13)=0
      ATRIB(53)=0
   ENDIF
   IF (ATRIB(13) .GT. 1 .AND. XX(14) .EQ. ATRIB(1)) THEN
      ATRIB(53)=1
      ATRIB(13)=0
      IF (SHOTS3 .GT. 6) THEN
         XX(14)=10
         ATRIB(53)=0
      ENDIF
   ENDIF
C  ------------- THREAT 4 -------------
   RNG4= SQRT((ATRIB(6)-XX(15))**2+(ATRIB(7)-XX(16))**2)
   RNGE4=XX(17)-UNFRM(0.0,980.0,4)
   IF (RNG4 .LE. RNGE4) THEN
      ATRIB(14)=ATRIB(14)+1
      IF (XX(18) .LT. 1.0)THEN
         PICKIT=UNFRM(0.0,1.0,4)
         IF (PICKIT .LT. (1/XX(38)))XX(18)=ATRIB(1)
         IF (XX(18) .EQ. XX(14))XX(18)=0
      ENDIF
   ELSE
      ATRIB(14)=0
      ATRIB(54)=0
   ENDIF
   IF (ATRIB(14) .GT. 1 .AND. XX(18) .EQ. ATRIB(1)) THEN
      ATRIB(54)=1
      ATRIB(14)=0
      IF (SHOTS4 .GT. 6) THEN
         XX(18)=10
         ATRIB(54)=0
      ENDIF
   ENDIF
   RETURN
C  *******************************************************
```

```
C
C      ***************  EVENT (11)  THREAT 1  ***************
C         THIS LOGIC REFLECTS THE PK GRID MAP OBTAINED FROM
C         AFATL/ENYS.  PROBABILITIES OF KILL FOR 200 FT AND
C         1000 FT AVERAGE TO 0.06 AND 0.14 RESPECTIVELY.
C
150    XX(25)=XX(25)-1
       ECM=1.0
       PROBE=UNFRM(0.0,1.0,1)
       IF (ATRIB(1) .LT. 10 .AND. PROBE .GT. 0.25) ECM=2
       ALT=1
       IF (ATRIB(42) .GT. 1000) ALT=2
       RMAX=81000
       RINC=9000
       MISSX=XX(3)
       MISSY=XX(4)
       CALL GRIDLOC
       RELIAB1=UNFRM(0.0,1.0,1)
       RELIAB2=UNFRM(0.0,1.0,1)
       PKILL1=PKILL
       PKILL2=PKILL
       IF (RELIAB1 .GT. 0.765) PKILL1=0
       IF (RELIAB2 .GT. 0.765) PKILL2=0
       IF (PKILL1 .GT. 0) THEN
          PKMISS1=(PKILL1-0.5+UNFRM(0.0,1.0,1))/10
       ELSE
          PKMISS1=0
       ENDIF
       IF (PKILL2 .GT. 0) THEN
          PKMISS2=(PKILL2-0.5+UNFRM(0.0,1.0,1))/10
       ELSE
          PKMISS2=0
       ENDIF
       IF (ATRIB(1) .GT. 10) THEN
          PKMISS1=PKMISS1/XX(61)
          PKMISS2=PKMISS2/XX(61)
       ENDIF
       PKMISS1=PKMISS1/ATRIB(4)**0.5
       PKMISS2=PKMISS2/ATRIB(4)**0.5
       HIT1=UNFRM(0.0,1.0,1)
       HIT2=UNFRM(0.0,1.0,1)
       IF(HIT1.LE. PKMISS1 .OR. HIT2 .LE. PKMISS2)ATRIB(36)=0
       RETURN
C      ****************************************************
C
C      ***************  EVENT (12)  THREAT 2  ***************
C         THIS LOGIC REFLECTS THE PK GRID MAP OBTAINED FROM
C         AFATL/ENYS.  PROBABILITIES OF KILL FOR 200 FT AND
C         1000 FT AVERAGE TO 0.22 AND 0.43 RESPECTIVELY.
C
160    XX(26)=XX(26)-1
       ECM=1.0
       PROBE=UNFRM(0.0,1.0,2)
```

```
      IF (ATRIB(1) .LT. 10 .AND. PROBE .GT. 0.75) ECM=2
      ALT=1
      IF (ATRIB(42) .GT. 1000) ALT=2
      RMAX=108000
      RINC=12000
      MISSX=XX(7)
      MISSY=XX(8)
      CALL GRIDLOC
      RELIAB1=UNFRM(0.0,1.0,2)
      RELIAB2=UNFRM(0.0,1.0,2)
      PKILL1=PKILL
      PKILL2=PKILL
      IF (RELIAB1 .GT. 0.81) PKILL1=0
      IF (RELIAB2 .GT. 0.81) PKILL2=0
      IF (PKILL1 .GT. 0) THEN
         PKMISS1=(PKILL1-0.5+UNFRM(0.0,1.0,2))/10
      ELSE
         PKMISS1=0
      ENDIF
      IF (PKILL2 .GT. 0) THEN
         PKMISS2=(PKILL2-0.5+UNFRM(0.0,1.0,2))/10
      ELSE
         PKMISS2=0
      ENDIF
      IF (ATRIB(1) .GT. 10) THEN
        PKMISS1=PKMISS1/XX(62)
        PKMISS2=PKMISS2/XX(62)
      ENDIF
      PKMISS1=PKMISS1/ATRIB(4)**0.5
      PKMISS2=PKMISS2/ATRIB(4)**0.5
      HIT1=UNFRM(0.0,1.0,2)
      HIT2=UNFRM(0.0,1.0,2)
      IF(HIT1.LE. PKMISS1 .OR. HIT2 .LE. PKMISS2)ATRIB(36)=0
      RETURN
C     ****************************************************
C
C     ****************  EVENT(13) THREAT 3  ****************
170   RANGE= SQRT((ATRIB(6)-XX(11))**2+(ATRIB(7)-XX(12))**2)
      ECM=1.0
      SHOTS3=SHOTS3+1
      PKGUN=XX(65)
      PKMISS=PKGUN
      IF(RANGE .LT. 2100)PKMISS=(PKGUN/1500)*(RANGE-600)
      IF(RANGE.GT.7500)PKMISS=PKGUN-(PKGUN/2300)*
     1                       (RANGE-7500)
      IF(ATRIB(42) .LT. 500)PKMISS=(PKMISS*ATRIB(42))/500
      IF(ATRIB(1) .GT. 10) PKMISS = PKMISS/XX(63)
      PKMISS = PKMISS/ATRIB(4)**.5
      HIT= UNFRM(0.0,1.0,3)
      IF (HIT .LE. PKMISS) ATRIB(36)=0
      RETURN
C     ****************************************************
C
```

```
C     ****************  EVENT(14) THREAT 4  ****************
180   RANGE= SQRT((ATRIB(6)-XX(15))**2+(ATRIB(7)-XX(16))**2)
      ECM=1.0
      SHOTS4=SHOTS4+1
      PKGUN=XX(65)
      PKMISS=PKGUN
      IF(RANGE .LT. 2100)PKMISS=(PKGUN/1500)*(RANGE-600)
      IF(RANGE.GT.7500)PKMISS=PKGUN-(PKGUN/2300)*
     1                            (RANGE-7500)
      IF(ATRIB(42) .LT. 500)PKMISS=(PKMISS*ATRIB(42))/500
      IF(ATRIB(1) .GT. 10) PKMISS = PKMISS/XX(63)
      PKMISS = PKMISS/ATRIB(4)**.5
      HIT= UNFRM(0.0,1.0,4)
      IF (HIT .LE. PKMISS) ATRIB(36)=0
      RETURN
      END
C     ******************************************************
C
C     *********************  INTLC  ************************
      SUBROUTINE INTLC
      INTEGER THREATA,THREATB,SHOTS3,SHOTS4
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
     1MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),
     2SSL(100),TNEXT,TNOW,XX(100)
      COMMON/GRID/THREATA(19,6,2,2),THREATB(19,6,2,2)
      OPEN (UNIT=11,FILE='GST86M:[DCOULTER.FLY]THREAT.A',
     1      STATUS='OLD')
      READ(11,10)THREATA
10    FORMAT(19I3)
      CLOSE (UNIT=11)
      OPEN (UNIT=12,FILE='GST86M:[DCOULTER.FLY]THREAT.B',
     1      STATUS='OLD')
      READ(12,10)THREATB
      CLOSE (UNIT=12)
      RETURN
      END
C     ******************************************************
C     ******************************************************
C
C     *********************  OUTPUT  ***********************
      SUBROUTINE OTPUT
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
     1MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),
     2SSL(100),TNEXT,TNOW,XX(100)
      RETURN
      END
C     ******************************************************
C
C     **********************  GRIDLOC  *********************
      SUBROUTINE GRIDLOC
C        ---------------------------------------------------
C                  CALLED BY EVENT 11 AND EVENT 12.
C        ---------------------------------------------------
```

```
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
     1MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),
     2SSL(100),TNEXT,TNOW,XX(100)
      COMMON/GRID/THREATA(19,6,2,2),THREATB(19,6,2,2)
      COMMON/LOCA/MISSX,MISSY,PKILL,RMAX,ALT,ECM,RINC
      INTEGER THREATA,THREATB,ECM,TRACK,ALT,RANGE,RMAX,RINC
      REAL LATDIS,MISSX,MISSY
      DELX=ATRIB(6)-MISSX
      DELY=ATRIB(7)-MISSY
      DIST=SQRT(DELX**2+DELY**2)
      IF (DELX .EQ. 0 ) THEN
         BEAR=0
         IF (DELY .GT. 0) BEAR=180
         GO TO 30
      ENDIF
      SLOPE=DELY/DELX
      BEAR=90-57.3*ATAN(SLOPE)
      IF (ATRIB(6) .GT. MISSX) BEAR=BEAR+180
30    DELTAH=ABS(ATRIB(19)-BEAR)
      LATDIS=DIST*SIN(DELTAH/57.3)
      RNGDIS=DIST*COS(DELTAH/57.3)*-1
      TRACK=INT(LATDIS/8700)+1
      IF (TRACK .GT. 5) TRACK=6
      RNGDIS=RNGDIS+RMAX
      RANGE=INT(RNGDIS/RINC)+1
      IF (RANGE .LT. 1 .OR. RANGE .GT. 18)RANGE=19
      IF (RINC.LT. 10000) PKILL=THREATA(RANGE,TRACK,ALT,ECM)
      IF (RINC.GT. 10000) PKILL=THREATB(RANGE,TRACK,ALT,ECM)
      RETURN
      END
C     ***********************************************************
C
C     ****************  CIRCLE COORDINATES  ****************
      SUBROUTINE CIRCOORDS
C        ---------------------------------------------------
C                         CALLED BY EVENT 1.
C        ---------------------------------------------------
      COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
     1MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),
     2SSL(100),TNEXT,TNOW,XX(100)
      COMMON/ROLL/ITURN, RADIUS
      DIMENSION CIRX(4),CIRY(4)
      PI=3.14159
      ANGLE=ATRIB(21)/57.295 + PI/2
      CIRX(1)=ATRIB(23)+RADIUS*SIN(ANGLE)
      CIRY(1)=ATRIB(24)+RADIUS*COS(ANGLE)
      ANGLE2=ATRIB(20)/57.295 +PI/2
      CIRX(3)=ATRIB(34)+RADIUS*SIN(ANGLE2)
      CIRY(3)=ATRIB(35)+RADIUS*COS(ANGLE2)
      ANGLE=ANGLE-PI
      CIRX(2)=ATRIB(23)+RADIUS*SIN(ANGLE)
      CIRY(2)=ATRIB(24)+RADIUS*COS(ANGLE)
      ANGLE2=ANGLE2-PI
```

```
      CIRX(4)=ATRIB(34)+RADIUS*SIN(ANGLE2)
      CIRY(4)=ATRIB(35)+RADIUS*COS(ANGLE2)
      ROOT1=SQRT((ATRIB(30)-CIRX(4))**2+
     1          (ATRIB(31)-CIRY(4))**2)
      ROOT2=SQRT((ATRIB(30)-CIRX(3))**2+
     1          (ATRIB(31)-CIRY(3))**2)
C     ------------------ FIRST TURN LEFT ----------------
      IF (ROOT1 .LE. ROOT2) THEN
         ATRIB(25)=CIRX(4)
         ATRIB(26)=CIRY(4)
         ATRIB(15)=-1
         ATRIB(27)=CIRX(2)
         ATRIB(28)=CIRY(2)
         ATRIB(16)=-1
C     ---------- LEFT/LEFT -----------
         ATRIB(2)=1
         ANGLE=(CIRY(4)-CIRY(2))/(CIRX(4)-CIRX(2))
         ANGLE2=(ATRIB(24)-ATRIB(31))/(ATRIB(23)-ATRIB(30))
         IF (ANGLE .GT. ANGLE2) THEN
            ATRIB(27)=CIRX(1)
            ATRIB(28)=CIRY(1)
            ATRIB(16)=1
C     ---------- LEFT/RIGHT ----------
            ATRIB(2)=2
         ENDIF
C     ------------------ FIRST TURN RIGHT ----------------
      ELSE
         ATRIB(25)=CIRX(3)
         ATRIB(26)=CIRY(3)
         ATRIB(15)=1
         ATRIB(27)=CIRX(1)
         ATRIB(28)=CIRY(1)
         ATRIB(16)=1
C    ---------- RIGHT/RIGHT ----------
         ATRIB(2)=4
         ANGLE=(CIRY(3)-CIRY(1))/(CIRX(3)-CIRX(1))
         ANGLE2=(ATRIB(24)-ATRIB(31))/(ATRIB(23)-ATRIB(30))
         IF (ANGLE .LT. ANGLE2) THEN
            ATRIB(27)=CIRX(2)
            ATRIB(28)=CIRY(2)
            ATRIB(16)=-1
C     ---------- RIGHT/LEFT ----------
            ATRIB(2)=3
         ENDIF
      ENDIF
      RETURN
      END
C     *****************************************************
C
C     *************** ROLLOUT CALCULATIONS ****************
      SUBROUTINE ROLLOUTS
C       ---------------------------------------------------
C                       CALLED BY EVENT 1.
```

```
C       --------------------------------------------------
        COMMON/SCOM1/ATRIB(100),DD(100),DDL(100),DTNOW,II,MFA,
       1MSTOP,NCLNR,NCRDR,NPRNT,NNRUN,NNSET,NTAPE,SS(100),
       2SSL(100),TNEXT,TNOW,XX(100)
        COMMON/ROLL/ITURN, RADIUS
        GO TO (11,12,21,11), ITURN
C       ----------  LEFT/LEFT OR RIGHT/RIGHT  ----------
11      ATRIB(17)=ATAN((ATRIB(26)-ATRIB(28))/
       1              (ATRIB(25)-ATRIB(27)))
        RETURN
C       ----------  LEFT/RIGHT  ----------
12      ANGLE=ATAN((ATRIB(26)-ATRIB(28))/
       1          (ATRIB(25)-ATRIB(27)))
        DELTAH=ASIN((2*RADIUS)/SQRT((ATRIB(26)-ATRIB(28))**2
       1           +(ATRIB(25)-ATRIB(27))**2))
        ATRIB(17)=ANGLE+DELTAH
        RETURN
C       ----------  RIGHT/LEFT  ----------
21      ANGLE=ATAN((ATRIB(26)-ATRIB(28))/
       1           (ATRIB(25)-ATRIB(27)))
        DELTAH=ASIN((2*RADIUS)/SQRT((ATRIB(26)-ATRIB(28))**2
       1           +(ATRIB(25)-ATRIB(27))**2))
        ATRIB(17)=ANGLE-DELTAH
        RETURN
        END
C       **************************************************
```

Appendix D: Engagement Grid Files

1. Threat.a

0	0	0	0	3	3	2	1	0	0	0	3	7	5	2	0	0	0	0
0	0	0	0	3	4	3	2	1	1	2	4	7	5	2	0	0	0	0
0	0	0	0	0	3	3	2	2	2	3	5	6	5	2	0	0	0	0
0	0	0	0	0	0	3	3	3	3	3	2	1	0	0	0	0	0	0
0	0	0	0	0	0	1	2	2	2	1	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1	5	7	7	4	3	2	0	0	0	1	5	7	8	7	3	0	0
0	1	6	7	8	5	4	3	2	2	2	6	8	8	8	6	3	0	0
0	0	2	6	7	4	4	3	2	2	3	7	8	9	8	8	3	0	0
0	0	2	6	8	8	6	3	3	2	3	7	9	9	8	5	2	0	0
0	0	0	2	6	6	6	2	2	2	2	6	8	7	3	1	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1	2	1	0	0	0	0	1	3	1	0	0	0	0	0
0	0	0	0	1	2	2	1	0	0	1	2	2	1	0	0	0	0	0
0	0	0	0	1	2	2	2	1	1	2	2	1	1	0	0	0	0	0
0	0	0	0	0	1	1	2	2	2	2	1	1	0	0	0	0	0	0
0	0	0	0	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	1	2	2	3	1	1	0	0	0	4	2	2	2	1	0	0	0
0	0	1	2	2	2	1	1	1	1	2	2	2	2	1	1	0	0	0
0	0	0	1	2	2	3	1	1	1	1	2	1	1	1	0	0	0	0
0	0	0	1	2	2	2	2	2	2	2	2	1	1	0	0	0	0	0
0	0	0	0	1	1	1	1	2	2	2	1	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

2. Threat.b

0	0	1	4	6	4	2	1	0	0	0	3	8	8	2	0	0	0	0
0	0	1	5	7	4	3	2	1	1	2	3	8	8	2	0	0	0	0
0	0	0	3	7	6	5	4	2	1	2	4	7	7	1	0	0	0	0
0	0	0	3	6	6	6	5	3	2	2	4	7	6	1	0	0	0	0
0	0	0	2	5	6	6	5	3	3	2	3	6	2	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	7	8	8	8	6	4	1	0	0	1	5	7	8	8	6	3	0	0
1	8	8	9	8	6	4	2	2	1	2	6	7	8	8	6	3	0	0
1	7	8	9	9	8	6	3	2	2	3	7	8	9	9	7	3	0	0
0	2	8	9	9	8	7	6	6	7	7	8	9	9	9	6	1	0	0
0	2	7	8	8	8	6	6	6	6	7	8	9	9	7	6	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	2	5	3	1	1	0	0	0	2	7	7	1	0	0	0	0
0	0	1	3	6	3	2	1	1	1	1	2	7	7	1	0	0	0	0
0	0	0	3	6	5	4	3	1	1	2	3	6	6	1	0	0	0	0
0	0	0	2	5	5	5	5	3	2	2	4	7	6	1	0	0	0	0
0	0	0	2	4	5	5	5	3	3	2	3	6	2	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	5	7	7	7	4	3	1	0	0	1	5	6	7	7	5	2	0	0
0	7	7	8	7	5	3	1	1	1	2	5	6	7	7	5	2	0	0
1	6	7	8	8	7	5	2	2	1	2	6	7	8	8	6	2	0	0
0	2	7	8	8	8	7	6	6	7	7	8	9	9	9	6	1	0	0
0	2	7	8	8	8	6	6	6	6	7	8	9	9	7	6	1	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Appendix E: SAM Engagement Grids

Kill Probability Key

Number	Interval
0	$0.00 \leq Pk < 0.05$
1	$0.05 \leq Pk < 0.15$
2	$0.15 \leq Pk < 0.25$
3	$0.25 \leq Pk < 0.35$
4	$0.35 \leq Pk < 0.45$
5	$0.45 \leq Pk < 0.55$
6	$0.55 \leq Pk < 0.65$
7	$0.65 \leq Pk < 0.75$
8	$0.75 \leq Pk < 0.85$
9	$0.85 \leq Pk < 0.95$
10	$0.95 \leq Pk < 1.00$

Threat 1 - Below 1000 ft/No ECM

FLIGHT / RANGE	8700	17400	26100	34800	43500
-81000	0	0	0	0	0
-72000	0	0	0	0	0
-63000	0	0	0	0	0
-54000	0	0	0	0	0
-45000	3	0	0	0	0
-36000	3	4	3	0	0
-27000	2	3	3	3	1
-18000	1	2	2	3	2
-9000	0	1	2	3	2
THREAT	0	1	2	3	2
9000	0	2	3	3	1
18000	3	4	5	2	0
27000	7	7	6	1	0
36000	5	5	5	0	0
45000	2	2	2	0	0
54000	0	0	0	0	0
63000	0	0	0	0	0
72000	0	0	0	0	0
81000	0	0	0	0	0

RADIUS OF CLOSEST APPROACH (RCA)

Threat 1 - Below 1000 ft/Active ECM

FLIGHT

RANGE	8700	17400	26100	34800	43500
-81000	0	0	0	0	0
-72000	0	0	0	0	0
-63000	0	0	0	0	0
-54000	0	0	0	0	0
-45000	1	1	1	0	0
-36000	2	2	2	1	0
-27000	1	2	2	1	0
-18000	0	1	2	2	1
-9000	0	0	1	2	1
THREAT	0	0	1	2	1
9000	0	1	2	2	0
18000	1	2	2	1	0
27000	3	2	1	1	0
36000	1	1	1	0	0
45000	0	0	0	0	0
54000	0	0	0	0	0
63000	0	0	0	0	0
72000	0	0	0	0	0
81000	0	0	0	0	0

RADIUS OF CLOSEST APPROACH (RCA)

Threat 1 - Above 1000 ft/No ECM

FLIGHT

RANGE	8700	17400	26100	34800	43500
-81000	0	0	0	0	0
-72000	1	1	0	0	0
-63000	5	6	2	2	0
-54000	7	7	6	6	2
-45000	7	8	7	8	6
-36000	4	5	4	8	6
-27000	3	4	4	6	6
-18000	2	3	3	3	2
-9000	0	2	2	3	2
THREAT	0	2	2	2	2
9000	0	2	3	3	2
18000	1	6	7	7	6
27000	5	8	8	9	8
36000	7	8	9	9	7
45000	8	8	8	8	3
54000	7	6	8	5	1
63000	3	3	3	2	0
72000	0	0	0	0	0
81000	0	0	0	0	0

RADIUS OF CLOSEST APPROACH (RCA)

Threat 1 - Above 1000 ft/Active ECM

FLIGHT

RANGE	8700	17400	26100	34800	43500
-81000	0	0	0	0	0
-72000	0	0	0	0	0
-63000	1	1	0	0	0
-54000	2	2	1	1	0
-45000	2	2	2	2	1
-36000	3	2	2	2	1
-27000	1	1	3	2	1
-18000	1	1	1	2	1
-9000	0	1	1	2	2
THREAT	0	1	1	2	2
9000	0	2	1	2	2
18000	4	2	2	2	1
27000	2	2	1	1	0
36000	2	2	1	1	0
45000	2	1	1	0	0
54000	1	1	0	0	0
63000	0	0	0	0	0
72000	0	0	0	0	0
81000	0	0	0	0	0

RADIUS OF CLOSEST APPROACH (RCA)

Threat 2 - Below 1000 ft/No ECM

FLIGHT

RANGE	8700	17400	26100	34800	43500
-81000	0	0	0	0	0
-72000	0	0	0	0	0
-63000	1	1	0	0	0
-54000	4	5	3	3	2
-45000	6	7	7	6	5
-36000	4	4	6	6	6
-27000	2	3	5	6	6
-18000	1	2	4	5	5
-9000	0	1	2	3	3
THREAT	0	1	1	2	3
9000	0	2	2	2	2
18000	3	3	4	4	3
27000	8	8	7	7	6
36000	8	8	7	6	2
45000	2	2	1	1	0
54000	0	0	0	0	0
63000	0	0	0	0	0
72000	0	0	0	0	0
81000	0	0	0	0	0

RADIUS OF CLOSEST APPROACH (RCA)

Threat 2 - Below 1000 ft/Active ECM

FLIGHT / RANGE					
-81000	0	0	0	0	0
-72000	0	0	0	0	0
-63000	0	1	0	0	0
-54000	2	3	3	2	2
-45000	5	6	6	5	4
-36000	3	3	5	5	5
-27000	1	2	4	5	5
-18000	1	1	3	5	5
-9000	0	1	1	3	3
THREAT	0	1	1	2	3
9000	0	1	2	2	2
18000	2	2	3	4	3
27000	7	7	6	7	6
36000	7	7	6	6	2
45000	1	1	1	1	0
54000	0	0	0	0	0
63000	0	0	0	0	0
72000	0	0	0	0	0
81000	0	0	0	0	0
RADIUS OF CLOSEST APPROACH (RCA)	8700	17400	26100	34800	43500

Threat 2 - Above 1000 ft/No ECM

FLIGHT / RANGE					
-81000	1	1	1	0	0
-72000	7	8	7	2	2
-63000	8	8	8	8	7
-54000	8	9	9	9	8
-45000	8	8	9	9	8
-36000	6	6	8	8	8
-27000	4	4	6	7	6
-18000	1	2	3	6	6
-9000	0	2	2	6	6
THREAT	0	1	2	7	6
9000	1	2	3	7	7
18000	5	6	7	8	8
27000	7	7	8	9	9
36000	8	8	9	9	9
45000	8	8	9	9	7
54000	6	6	7	6	6
63000	3	3	3	1	1
72000	0	0	0	0	0
81000	0	0	0	0	0
RADIUS OF CLOSEST APPROACH (RCA)	8700	17400	26100	34800	43500

Threat 2 - Above 1000 ft/Active ECM

FLIGHT

RANGE					
-81000	0	0	1	0	0
-72000	5	7	6	2	2
-63000	7	7	7	7	7
-54000	7	8	8	8	8
-45000	7	7	8	8	8
-36000	4	5	7	8	8
-27000	3	3	5	7	6
-18000	1	1	2	6	6
-9000	0	1	2	6	6
THREAT	0	1	1	7	6
9000	1	2	2	7	7
18000	5	5	6	8	8
27000	6	6	7	9	9
36000	7	7	8	9	9
45000	7	7	8	9	7
54000	5	5	6	6	6
63000	2	2	2	1	1
72000	0	0	0	0	0
81000	0	0	0	0	0
	8700	17400	26100	34800	43500

RADIUS OF CLOSEST APPROACH (RCA)

Appendix F: Sample SLAM Output

S L A M I I S U M M A R Y R E P O R T

SIMULATION PROJECT THESIS NETWORK   BY DCOULTER DFRY

DATE 1/10/1986   RUN NUMBER 1 OF 1

CURRENT TIME 0.9965E+05
STATISTICAL ARRAYS CLEARED AT TIME 0.0000E+00

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
THR 1 LAUNCH	0.156E+02	0.499E+01	0.320E+00	0.110E+02	0.220E+02	19
THR 1 KILLS	0.210E+02	0.000E+00	0.000E+00	0.210E+02	0.210E+02	1
THR 1 ACFT PK			NO VALUES	RECORDED		
THR 1 WEAP PK	0.526E-01	0.229E+00	0.436E+01	0.000E+00	0.100E+01	19
THR 2 LAUNCH	0.585E+01	0.684E+01	0.117E+01	0.100E+01	0.220E+02	111
THR 2 KILLS	0.212E+01	0.247E+01	0.117E+01	0.100E+01	0.120E+02	33
THR 2 ACFT PK	0.413E+00	0.496E+00	0.120E+01	0.000E+00	0.100E+01	75
THR 2 WEAP PK	0.556E-01	0.232E+00	0.418E+01	0.000E+00	0.100E+01	36
THR 3 BURSTS	0.137E+02	0.417E+01	0.304E+00	0.110E+02	0.220E+02	1151
THR 3 KILLS	0.145E+02	0.450E+01	0.310E+00	0.110E+02	0.210E+02	13
THR 3 ACFT PK			NO VALUES	RECORDED		
THR 3 WEAP PK	0.113E-01	0.106E+00	0.936E+01	0.000E+00	0.100E+01	1151
THR 4 BURSTS	0.163E+02	0.505E+01	0.310E+00	0.110E+02	0.220E+02	1104
THR 4 KILLS	0.192E+02	0.468E+01	0.244E+00	0.110E+02	0.220E+02	9
THR 4 ACFT PK			NO VALUES	RECORDED		
THR 4 WEAP PK	0.815E-02	0.900E-01	0.110E+02	0.000E+00	0.100E+01	1104
TOTAL KILLS	0.809E+01	0.810E+01	0.100E+01	0.100E+01	0.220E+02	56
PYLON STATUS	0.100E+01	0.100E+01	0.100E+01	0.000E+00	0.200E+01	31
PROB CLOSURE	0.926E+00	0.000E+00	0.000E+00	0.926E+00	0.926E+00	1
AIRCRAFT PK	0.775E-01	0.000E+00	0.000E+00	0.775E-01	0.775E-01	1
WEAPON PK	0.325E-01	0.000E+00	0.000E+00	0.325E-01	0.325E-01	1
FLIGHT TIME	0.957E+02	0.371E+02	0.388E+00	0.600E+01	0.150E+03	1169
WEAPONS LOST	0.165E+02	0.789E+01	0.477E+00	0.000E+00	0.310E+02	1169

FILE STATISTICS

FILE NUMBER	ASSOC NODE LABEL/TYPE	AVERAGE LENGTH	STANDARD DEVIATION	MAXIMUM LENGTH	CURRENT LENGTH	AVERAGE WAIT TIME
1		0.000	0.000	0	0	0.000
2	CALENDAR	2.161	2.087	10	0	0.163

REGULAR ACTIVITY STATISTICS

ACTIVITY INDEX/LABEL	AVERAGE UTILIZATION	STANDARD DEVIATION	MAXIMUM UTIL	CURRENT UTIL	ENTITY COUNT
1 AIRCRAFT 1	0.0000	0.0000	1	0	200
2 AIRCRAFT 2	0.0000	0.0000	1	0	200
11 AC 1/WPN 1	0.0000	0.0000	1	0	194
12 AC 1/WPN 2	0.0000	0.0000	1	0	194
13 AC 1/WPN 3	0.0000	0.0000	0	0	0
14 AC 1/WPN 4	0.0000	0.0000	0	0	0
15 WPNS RELEASE	0.0000	0.0000	1	0	769
18 TOT DESTROY	0.0000	0.0000	1	0	56
19 AC DESTROY	0.0000	0.0000	1	0	31
20 WPN DESTROY	0.0000	0.0000	1	0	25
21 AC 2/WPN 1	0.0000	0.0000	1	0	191
22 AC 2/WPN 2	0.0000	0.0000	1	0	190
23 AC 2/WPN 3	0.0000	0.0000	0	0	0
24 AC 2/WPN 4	0.0000	0.0000	0	0	0
29 AIRCRAFT	0.0000	0.0000	1	0	400
30 TOTAL	0.0000	0.0000	1	0	1169
31 THR1 ENGAGE	0.0066	0.0811	1	0	19
32 THR2 ENGAGE	0.0338	0.1992	3	0	111

HISTOGRAM NUMBER 1
THR 1 LAUNCH

```
OBS  RELA   UPPER
FREQ FREQ  CELL LIM 0         20        40        60        80       100
                    +    +    +    +    +    +    +    +    +    +    +
  0 0.000 0.100E+01 +                                                 +
  0 0.000 0.200E+01 +                                                 +
  0 0.000 0.300E+01 +                                                 +
  0 0.000 0.400E+01 +                                                 +
  0 0.000 0.500E+01 +                                                 +
  0 0.000 0.600E+01 +                                                 +
  0 0.000 0.700E+01 +                                                 +
  0 0.000 0.800E+01 +                                                 +
  0 0.000 0.900E+01 +                                                 +
  0 0.000 0.100E+02 +                                                 +
  6 0.316 0.110E+02 *****************                                 +
  5 0.263 0.120E+02 **************               C                    +
  0 0.000 0.130E+02 +                            C                    +
  0 0.000 0.140E+02 +                            C                    +
  0 0.000 0.150E+02 +                            C                    +
  0 0.000 0.160E+02 +                            C                    +
  0 0.000 0.170E+02 +                            C                    +
  0 0.000 0.180E+02 +                            C                    +
  0 0.000 0.190E+02 +                            C                    +
  0 0.000 0.200E+02 +                            C                    +
  6 0.316 0.210E+02 *****************                            C    +
  2 0.105 0.220E+02 ******                                            C
  0 0.000 0.230E+02 +                                                 C
  0 0.000 0.240E+02 +                                                 C
  0 0.000 0.250E+02 +                                                 C
  0 0.000     INF   +                                                 C
---                 +    +    +    +    +    +    +    +    +    +    +
 19                 0         20        40        60        80       100
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
THR 1 LAUNCH	0.156E+02	0.499E+01	0.320E+00	0.110E+02	0.220E+02	19

HISTOGRAM NUMBER 5
THR 2 LAUNCH

```
OBS  RELA    UPPER
FREQ FREQ  CELL LIM 0         20        40        60        80        100
                    +    +    +    +    +    +    +    +    +    +    +
 36 0.324 0.100E+01 +****************                                 +
 39 0.351 0.200E+01 +******************               C               +
  0 0.000 0.300E+01 +                                 C               +
  0 0.000 0.400E+01 +                                 C               +
  0 0.000 0.500E+01 +                                 C               +
  0 0.000 0.600E+01 +                                 C               +
  0 0.000 0.700E+01 +                                 C               +
  0 0.000 0.800E+01 +                                 C               +
  0 0.000 0.900E+01 +                                 C               +
  0 0.000 0.100E+02 +                                 C               +
 11 0.099 0.110E+02 +*****                                 C          +
 13 0.117 0.120E+02 +******                                      C    +
  0 0.000 0.130E+02 +                                            C    +
  0 0.000 0.140E+02 +                                            C    +
  0 0.000 0.150E+02 +                                            C    +
  0 0.000 0.160E+02 +                                            C    +
  0 0.000 0.170E+02 +                                            C    +
  0 0.000 0.180E+02 +                                            C    +
  0 0.000 0.190E+02 +                                            C    +
  0 0.000 0.200E+02 +                                            C    +
  6 0.054 0.210E+02 +***                                           C  +
  6 0.054 0.220E+02 +***                                              C
  0 0.000 0.230E+02 +                                                 C
  0 0.000 0.240E+02 +                                                 C
  0 0.000 0.250E+02 +                                                 C
  0 0.000       INF +                                                 C
---                 +    +    +    +    +    +    +    +    +    +    +
111                 0         20        40        60        80        100
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
THR 2 LAUNCH	0.585E+01	0.684E+01	0.117E+01	0.100E+01	0.220E+02	111

HISTOGRAM NUMBER 9
THR 3 BURSTS

```
OBS   RELA     UPPER
FREQ  FREQ   CELL LIM  0        20        40        60        80        100
                       +    +    +    +    +    +    +    +    +    +    +
   0 0.000 0.100E+01   +                                                  +
   0 0.000 0.200E+01   +                                                  +
   0 0.000 0.300E+01   +                                                  +
   0 0.000 0.400E+01   +                                                  +
   0 0.000 0.500E+01   +                                                  +
   0 0.000 0.600E+01   +                                                  +
   0 0.000 0.700E+01   +                                                  +
   0 0.000 0.800E+01   +                                                  +
   0 0.000 0.900E+01   +                                                  +
   0 0.000 0.100E+02   +                                                  +
 425 0.369 0.110E+02   +******************                                +
 469 0.407 0.120E+02   +********************                    C         +
   0 0.000 0.130E+02   +                                        C         +
   0 0.000 0.140E+02   +                                        C         +
   0 0.000 0.150E+02   +                                        C         +
   0 0.000 0.160E+02   +                                        C         +
   0 0.000 0.170E+02   +                                        C         +
   0 0.000 0.180E+02   +                                        C         +
   0 0.000 0.190E+02   +                                        C         +
   0 0.000 0.200E+02   +                                        C         +
 137 0.119 0.210E+02   +******                                       C    +
 120 0.104 0.220E+02   +*****                                             C
   0 0.000 0.230E+02   +                                                  C
   0 0.000 0.240E+02   +                                                  C
   0 0.000 0.250E+02   +                                                  C
   0 0.000     INF     +                                                  C
 ---                   +    +    +    +    +    +    +    +    +    +    +
 ***                   0        20        40        60        80        100
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
THR 3 BURSTS	0.137E+02	0.417E+01	0.304E+00	0.110E+02	0.220E+02	1151

HISTOGRAM NUMBER13
THR 4 BURSTS

```
OBS  RELA   UPPER
FREQ FREQ  CELL LIM 0         20        40        60        80        100
                    +    +    +    +    +    +    +    +    +    +    +
  0 0.000 0.100E+01 +                                                 +
  0 0.000 0.200E+01 +                                                 +
  0 0.000 0.300E+01 +                                                 +
  0 0.000 0.400E+01 +                                                 +
  0 0.000 0.500E+01 +                                                 +
  0 0.000 0.600E+01 +                                                 +
  0 0.000 0.700E+01 +                                                 +
  0 0.000 0.800E+01 +                                                 +
  0 0.000 0.900E+01 +                                                 +
  0 0.000 0.100E+02 +                                                 +
270 0.245 0.110E+02 +************                                     +
310 0.281 0.120E+02 +**************           C                       +
  0 0.000 0.130E+02 +                         C                       +
  0 0.000 0.140E+02 +                         C                       +
  0 0.000 0.150E+02 +                         C                       +
  0 0.000 0.160E+02 +                         C                       +
  0 0.000 0.170E+02 +                         C                       +
  0 0.000 0.180E+02 +                         C                       +
  0 0.000 0.190E+02 +                         C                       +
  0 0.000 0.200E+02 +                         C                       +
213 0.193 0.210E+02 +**********                         C             +
311 0.282 0.220E+02 +**************                                   C
  0 0.000 0.230E+02 +                                                 C
  0 0.000 0.240E+02 +                                                 C
  0 0.000 0.250E+02 +                                                 C
  0 0.000    INF    +                                                 C
---                 +    +    +    +    +    +    +    +    +    +    +
***                 0         20        40        60        80        100
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
THR 4 BURSTS	0.163E+02	0.505E+01	0.310E+00	0.110E+02	0.220E+02	1104

HISTOGRAM NUMBER 2
THR 1 KILLS

```
OBS  RELA    UPPER
FREQ FREQ  CELL LIM 0         20        40        60        80        100
                    +    +    +    +    +    +    +    +    +    +    +
  0 0.000 0.100E+01 +                                                  +
  0 0.000 0.200E+01 +                                                  +
  0 0.000 0.300E+01 +                                                  +
  0 0.000 0.400E+01 +                                                  +
  0 0.000 0.500E+01 +                                                  +
  0 0.000 0.600E+01 +                                                  +
  0 0.000 0.700E+01 +                                                  +
  0 0.000 0.800E+01 +                                                  +
  0 0.000 0.900E+01 +                                                  +
  0 0.000 0.100E+02 +                                                  +
  0 0.000 0.110E+02 +                                                  +
  0 0.000 0.120E+02 +                                                  +
  0 0.000 0.130E+02 +                                                  +
  0 0.000 0.140E+02 +                                                  +
  0 0.000 0.150E+02 +                                                  +
  0 0.000 0.160E+02 +                                                  +
  0 0.000 0.170E+02 +                                                  +
  0 0.000 0.180E+02 +                                                  +
  0 0.000 0.190E+02 +                                                  +
  0 0.000 0.200E+02 +                                                  +
  1 1.000 0.210E+02 +**************************************************
  0 0.000 0.220E+02 +                                                  C
  0 0.000 0.230E+02 +                                                  C
  0 0.000 0.240E+02 +                                                  C
  0 0.000 0.250E+02 +                                                  C
  0 0.000 0.260E+02 +                                                  C
  0 0.000    INF    +                                                  C
---                 +    +    +    +    +    +    +    +    +    +    +
  1                 0         20        40        60        80        100
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
THR 1 KILLS	0.210E+02	0.000E+00	0.000E+00	0.210E+02	0.210E+02	1

```
                         **HISTOGRAM NUMBER 6**
                              THR 2 KILLS

OBS   RELA     UPPER
FREQ  FREQ   CELL LIM 0         20        40        60        80        100
                      +    +    +    +    +    +    +    +    +    +    +
 15 0.455  0.100E+01 +**********************                              +
 16 0.485  0.200E+01 +***********************                          C  +
  0 0.000  0.300E+01 +                                                 C  +
  0 0.000  0.400E+01 +                                                 C  +
  0 0.000  0.500E+01 +                                                 C  +
  0 0.000  0.600E+01 +                                                 C  +
  0 0.000  0.700E+01 +                                                 C  +
  0 0.000  0.800E+01 +                                                 C  +
  0 0.000  0.900E+01 +                                                 C  +
  0 0.000  0.100E+02 +                                                 C  +
  1 0.030  0.110E+02 +**                                                C +
  1 0.030  0.120E+02 +**                                                  C
  0 0.000  0.130E+02 +                                                    C
  0 0.000  0.140E+02 +                                                    C
  0 0.000  0.150E+02 +                                                    C
  0 0.000  0.160E+02 +                                                    C
  0 0.000  0.170E+02 +                                                    C
  0 0.000  0.180E+02 +                                                    C
  0 0.000  0.190E+02 +                                                    C
  0 0.000  0.200E+02 +                                                    C
  0 0.000  0.210E+02 +                                                    C
  0 0.000  0.220E+02 +                                                    C
  0 0.000  0.230E+02 +                                                    C
  0 0.000  0.240E+02 +                                                    C
  0 0.000  0.250E+02 +                                                    C
  0 0.000  0.260E+02 +                                                    C
  0 0.000     INF    +                                                    C
---                  +    +    +    +    +    +    +    +    +    +    +
 33                  0         20        40        60        80        100
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
THR 2 KILLS	0.212E+01	0.247E+01	0.117E+01	0.100E+01	0.120E+02	33

HISTOGRAM NUMBER10
THR 3 KILLS

```
OBS  RELA   UPPER
FREQ FREQ  CELL LIM 0         20        40        60        80       100
                    +    +    +    +    +    +    +    +    +    +    +
  0 0.000 0.100E+01 +                                                 +
  0 0.000 0.200E+01 +                                                 +
  0 0.000 0.300E+01 +                                                 +
  0 0.000 0.400E+01 +                                                 +
  0 0.000 0.500E+01 +                                                 +
  0 0.000 0.600E+01 +                                                 +
  0 0.000 0.700E+01 +                                                 +
  0 0.000 0.800E+01 +                                                 +
  0 0.000 0.900E+01 +                                                 +
  0 0.000 0.100E+02 +                                                 +
  3 0.231 0.110E+02 *************                                     +
  6 0.462 0.120E+02 ************************           C              +
  0 0.000 0.130E+02 +                                  C              +
  0 0.000 0.140E+02 +                                  C              +
  0 0.000 0.150E+02 +                                  C              +
  0 0.000 0.160E+02 +                                  C              +
  0 0.000 0.170E+02 +                                  C              +
  0 0.000 0.180E+02 +                                  C              +
  0 0.000 0.190E+02 +                                  C              +
  0 0.000 0.200E+02 +                                  C              +
  4 0.308 0.210E+02 ****************                                  C
  0 0.000 0.220E+02 +                                                 C
  0 0.000 0.230E+02 +                                                 C
  0 0.000 0.240E+02 +                                                 C
  0 0.000 0.250E+02 +                                                 C
  0 0.000 0.260E+02 +                                                 C
  0 0.000       INF +                                                 C
---                 +    +    +    +    +    +    +    +    +    +    +
 13                 0         20        40        60        80       100
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
THR 3 KILLS	0.145E+02	0.450E+01	0.310E+00	0.110E+02	0.210E+02	13

HISTOGRAM NUMBER14

THR 4 KILLS

```
OBS  RELA   UPPER
FREQ FREQ  CELL LIM  0         20        40        60        80        100
                     +    +    +    +    +    +    +    +    +    +    +
   0 0.000 0.100E+01 +                                                 +
   0 0.000 0.200E+01 +                                                 +
   0 0.000 0.300E+01 +                                                 +
   0 0.000 0.400E+01 +                                                 +
   0 0.000 0.500E+01 +                                                 +
   0 0.000 0.600E+01 +                                                 +
   0 0.000 0.700E+01 +                                                 +
   0 0.000 0.800E+01 +                                                 +
   0 0.000 0.900E+01 +                                                 +
   0 0.000 0.100E+02 +                                                 +
   2 0.222 0.110E+02 +***********                                      +
   0 0.000 0.120E+02 +          C                                      +
   0 0.000 0.130E+02 +          C                                      +
   0 0.000 0.140E+02 +          C                                      +
   0 0.000 0.150E+02 +          C                                      +
   0 0.000 0.160E+02 +          C                                      +
   0 0.000 0.170E+02 +          C                                      +
   0 0.000 0.180E+02 +          C                                      +
   0 0.000 0.190E+02 +          C                                      +
   0 0.000 0.200E+02 +          C                                      +
   3 0.333 0.210E+02 +*****************          C                     +
   4 0.444 0.220E+02 +**********************                           C
   0 0.000 0.230E+02 +                                                 C
   0 0.000 0.240E+02 +                                                 C
   0 0.000 0.250E+02 +                                                 C
   0 0.000 0.260E+02 +                                                 C
   0 0.000    INF    +                                                 C
 ---                 +    +    +    +    +    +    +    +    +    +    +
   9                 0         20        40        60        80        100
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
THR 4 KILLS	0.192E+02	0.468E+01	0.244E+00	0.110E+02	0.220E+02	9

```
                              **HISTOGRAM NUMBER18**
                                   PYLON STATUS

OBS  RELA    UPPER
FREQ FREQ   CELL LIM 0        20        40        60        80        100
                     +    +    +    +    +    +    +    +    +    +    +
 15 0.484 0.000E+00 +************************                          +
  1 0.032 0.100E+01 +**                        C                       +
 15 0.484    INF    +************************                          C
---                  +    +    +    +    +    +    +    +    +    +    +
 31                  0        20        40        60        80        100


               **STATISTICS FOR VARIABLES BASED ON OBSERVATION**

                         MEAN      STANDARD  COEFF. OF  MINIMUM     MAXIMUM   NO.OF
                         VALUE     DEVIATION VARIATION   VALUE       VALUE     OBS

PYLON STATUS           0.100E+01 0.100E+01 0.100E+01 0.000E+00 0.200E+01     31
```

HISTOGRAM NUMBER17
TOTAL KILLS

```
OBS  RELA   UPPER
FREQ FREQ  CELL LIM 0         20        40        60        80        100
                    +    +    +    +    +    +    +    +    +    +    +
 15 0.268 0.100E+01 **************                                    +
 16 0.286 0.200E+01 ***************             C                     +
  0 0.000 0.300E+01 +                           C                     +
  0 0.000 0.400E+01 +                           C                     +
  0 0.000 0.500E+01 +                           C                     +
  0 0.000 0.600E+01 +                           C                     +
  0 0.000 0.700E+01 +                           C                     +
  0 0.000 0.800E+01 +                           C                     +
  0 0.000 0.900E+01 +                           C                     +
  0 0.000 0.100E+02 +                           C                     +
  6 0.107 0.110E+02 ******                            C               +
  7 0.125 0.120E+02 *******                                 C         +
  0 0.000 0.130E+02 +                                       C         +
  0 0.000 0.140E+02 +                                       C         +
  0 0.000 0.150E+02 +                                       C         +
  0 0.000 0.160E+02 +                                       C         +
  0 0.000 0.170E+02 +                                       C         +
  0 0.000 0.180E+02 +                                       C         +
  0 0.000 0.190E+02 +                                       C         +
  0 0.000 0.200E+02 +                                       C         +
  8 0.143 0.210E+02 ********                                       C  +
  4 0.071 0.220E+02 *****                                             C
  0 0.000 0.230E+02 +                                                 C
  0 0.000 0.240E+02 +                                                 C
  0 0.000 0.250E+02 +                                                 C
  0 0.000    INF    +                                                 C
---                 +    +    +    +    +    +    +    +    +    +    +
 56                 0         20        40        60        80        100
```

STATISTICS FOR VARIABLES BASED ON OBSERVATION

	MEAN VALUE	STANDARD DEVIATION	COEFF. OF VARIATION	MINIMUM VALUE	MAXIMUM VALUE	NO.OF OBS
TOTAL KILLS	0.809E+01	0.810E+01	0.100E+01	0.100E+01	0.220E+02	56

Appendix G: Flight Path Verification

20 NM TERMINAL AREA STANDOFF PROFILE FLOWN FROM A 90 ENTRY.

		-- THREATS --				COORDINATES						
ID	TOF	1	2	3	4	X	Y	VEL	HDG	P	ALT	RANGE
1	0	0	0	0	0	-120000	3	885	90	0	200	120000
2	0	0	0	0	0	-119857	-5859	885	90	0	200	120000
1	1	0	0	0	0	-119115	3	885	90	0	200	119115
2	1	0	1	0	0	-118972	-5859	885	90	0	200	119116
1	2	0	0	0	0	-118230	3	885	90	0	200	118230
2	2	0	2	0	0	-118087	-5859	885	90	0	200	118232
1	3	0	0	0	0	-117345	3	885	90	0	200	117345
2	3	0	0	0	0	-117202	-5859	885	90	0	200	117348
1	4	0	0	0	0	-116460	3	885	90	0	200	116460
2	4	0	1	0	0	-116317	-5859	885	90	0	200	116464
1	5	0	0	0	0	-115575	3	885	90	0	200	115575
2	5	0	0	0	0	-115432	-5859	885	90	0	200	115580
1	6	0	0	0	0	-114690	3	885	90	0	200	114690
2	6	0	1	0	0	-114547	-5859	885	90	0	200	114697
1	7	0	1	0	0	-113805	3	885	90	0	200	113805
2	7	0	0	0	0	-113662	-5859	885	90	0	200	113813
1	8	0	0	0	0	-112920	3	885	90	0	200	112920
2	8	0	1	0	0	-112777	-5859	885	90	0	200	112929
1	9	0	1	0	0	-112035	3	885	90	0	200	112035
2	9	0	2	0	0	-111892	-5859	885	90	0	200	112045
1	10	0	2	0	0	-111150	3	885	90	0	200	111150
2	10	0	3	0	0	-111007	-5859	885	90	0	200	111161
1	11	0	3	0	0	-110265	3	885	90	0	200	110265
2	11	0	4	0	0	-110122	-5859	885	90	0	200	110278
1	12	0	4	0	0	-109380	3	885	90	0	200	109380
2	12	0	5	0	0	-109237	-5859	885	90	0	200	109394
1	13	0	5	0	0	-108495	3	885	90	0	200	108495
2	13	0	6	0	0	-108352	-5859	885	90	0	200	108510
1	14	0	6	0	0	-107610	3	885	90	0	200	107610
2	14	0	7	0	0	-107467	-5859	885	90	0	200	107626
1	15	0	7	0	0	-106725	3	885	90	0	200	106725
2	15	0	8	0	0	-106582	-5859	885	90	0	200	106743
1	16	0	8	0	0	-105840	3	885	90	0	200	105840
2	16	0	9	0	0	-105697	-5859	885	90	0	200	105859
1	17	0	9	0	0	-104955	3	885	90	0	200	104955
2	17	0	10	0	0	-104812	-5859	885	90	0	200	104976
1	18	0	10	0	0	-104070	3	885	90	0	200	104070
2	18	0	11	0	0	-103927	-5859	885	90	0	200	104092
1	19	0	11	0	0	-103185	3	885	90	0	200	103185
2	19	0	12	0	0	-103042	-5859	885	90	0	200	103208
1	20	0	12	0	0	-102300	3	885	90	0	200	102300
2	20	0	13	0	0	-102157	-5859	885	90	0	200	102325
1	21	0	13	0	0	-101415	3	885	90	0	200	101415
2	21	0	14	0	0	-101272	-5859	885	90	0	200	101441
1	22	0	14	0	0	-100530	3	885	90	0	200	100530

2	22	0	15	0	0	-100387	-5859	885	90	0	200	100558
1	23	0	15	0	0	-99645	3	885	90	0	200	99645
2	23	0	16	0	0	-99502	-5859	885	90	0	200	99674
1	24	0	16	0	0	-98760	3	885	90	0	200	98760
2	24	0	17	0	0	-98617	-5859	885	90	0	200	98791
1	25	0	17	0	0	-97875	3	885	90	0	200	97875
2	25	0	18	0	0	-97732	-5859	885	90	0	200	97907
1	26	0	18	0	0	-96990	3	885	90	0	200	96990
2	26	0	19	0	0	-96847	-5859	885	90	0	200	97024
1	27	0	19	0	0	-96105	3	885	90	0	200	96105
2	27	0	20	0	0	-95962	-5859	885	90	0	200	96141
1	28	0	20	0	0	-95220	3	885	90	0	200	95220
2	28	0	21	0	0	-95077	-5859	885	90	0	200	95257
1	29	0	21	0	0	-94335	3	885	90	0	200	94335
2	29	0	22	0	0	-94192	-5859	885	90	0	200	94374
1	30	0	22	0	0	-93450	3	885	90	0	200	93450
2	30	0	23	0	0	-93307	-5860	885	90	0	200	93491
1	31	0	23	0	0	-92565	3	885	90	0	200	92565
2	31	0	24	0	0	-92422	-5860	885	90	0	200	92607
1	32	0	24	0	0	-91680	3	885	90	0	200	91680
2	32	0	25	0	0	-91537	-5860	885	90	0	200	91724
1	33	0	25	0	0	-90795	2	885	90	0	200	90795
2	33	0	26	0	0	-90652	-5860	885	90	0	200	90841
1	34	0	26	0	0	-89910	2	885	90	0	200	89910
2	34	0	27	0	0	-89767	-5860	885	90	0	200	89958
1	35	0	27	0	0	-89025	2	885	90	0	200	89025
2	35	0	28	0	0	-88882	-5860	885	90	0	200	89075
1	36	0	28	0	0	-88140	2	885	90	0	200	88140
2	36	0	29	0	0	-87997	-5860	885	90	0	200	88192
1	37	0	29	0	0	-87255	2	885	90	0	200	87255
2	37	0	30	0	0	-87112	-5860	885	90	0	200	87309
1	38	0	30	0	0	-86370	2	885	90	0	200	86370
2	38	0	31	0	0	-86227	-5860	885	90	0	200	86426
1	39	0	31	0	0	-85485	2	885	90	0	200	85485
2	39	0	32	0	0	-85342	-5860	885	90	0	200	85543
1	40	0	32	0	0	-84600	2	885	90	0	200	84600
2	40	0	33	0	0	-84457	-5860	885	90	0	200	84660
1	41	0	33	0	0	-83715	2	885	90	0	200	83715
2	41	0	34	0	0	-83572	-5860	885	90	0	200	83777
1	42	0	34	0	0	-82830	2	885	90	0	200	82830
2	42	0	35	0	0	-82687	-5860	885	90	0	200	82894
1	43	0	35	0	0	-81945	2	885	90	0	200	81945
2	43	0	36	0	0	-81802	-5860	885	90	0	200	82011
1	44	1	36	0	0	-81060	2	885	90	0	200	81060
2	44	0	37	0	0	-80917	-5860	885	90	0	200	81129
1	45	0	37	0	0	-80175	2	885	90	0	200	80175
2	45	1	38	0	0	-80032	-5860	885	90	0	200	80246
1	46	0	38	0	0	-79290	2	885	90	0	200	79290
2	46	0	39	0	0	-79147	-5860	885	90	0	200	79364
1	47	1	39	0	0	-78405	2	885	90	0	200	78405
2	47	1	40	0	0	-78262	-5860	885	90	0	200	78481
1	48	0	40	0	0	-77520	2	885	90	0	200	77520
2	48	2	41	0	0	-77377	-5860	885	90	0	200	77598

1	49	1	41	0	0	-76635	2	885	90	0	200	76635
2	49	3	42	0	0	-76492	-5860	885	90	0	200	76716
1	50	0	42	0	0	-75750	2	885	90	0	200	75750
2	50	0	43	0	0	-75607	-5860	885	90	0	200	75834
1	51	1	43	0	0	-74865	2	885	90	0	200	74865
2	51	0	44	0	0	-74722	-5860	885	90	0	200	74951
1	52	2	44	0	0	-73980	2	885	90	0	200	73980
2	52	1	45	0	0	-73837	-5860	885	90	0	200	74069
1	53	3	45	0	0	-73095	2	885	90	0	200	73095
2	53	0	46	0	0	-72952	-5860	885	90	0	200	73187
1	54	4	46	0	0	-72210	2	885	90	0	200	72210
2	54	1	47	0	0	-72067	-5860	885	90	0	200	72305
1	55	0	47	0	0	-71325	2	885	90	0	200	71325
2	55	2	48	0	0	-71182	-5860	885	90	0	200	71423
1	56	1	48	0	0	-70440	2	885	90	0	200	70440
2	56	3	49	0	0	-70297	-5860	885	90	0	200	70541
1	57	2	49	0	0	-69555	2	885	90	0	200	69555
2	57	4	50	0	0	-69412	-5860	885	90	0	200	69659
1	58	3	50	0	0	-68670	2	885	90	0	200	68670
2	58	5	51	0	0	-68527	-5860	885	90	0	200	68777
1	59	4	51	0	0	-67785	2	885	90	0	200	67785
2	59	6	52	0	0	-67642	-5860	885	90	0	200	67895
1	60	5	52	0	0	-66900	2	885	90	0	200	66900
2	60	7	53	0	0	-66757	-5860	885	90	0	200	67014
1	61	6	53	0	0	-66015	2	885	90	0	200	66015
2	61	8	54	0	0	-65872	-5860	885	90	0	200	66132
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2	62	9	55	0	0	-64987	-5860	885	90	0	200	65251
1	63	8	55	0	0	-64245	2	885	90	0	200	64245
2	63	10	56	0	0	-64102	-5860	885	90	0	200	64369
1	64	9	56	0	0	-63360	2	885	90	0	200	63360
2	64	11	57	0	0	-63217	-5860	885	90	0	200	63488
1	65	10	57	0	0	-62475	2	885	90	0	200	62475
2	65	12	58	0	0	-62332	-5860	885	90	0	200	62607
1	66	11	58	0	0	-61590	2	885	90	0	200	61590
2	66	13	59	0	0	-61447	-5860	885	90	0	200	61726
1	67	12	59	0	0	-60705	2	885	90	0	200	60705
2	67	14	60	0	0	-60562	-5860	885	90	0	200	60845
1	68	13	60	0	0	-59820	2	885	90	0	200	59820

	68.00	0.00	1.00	
11.00	1.00	885.00	2.00	58459.12
-59820.00	1.95	0.00	1.00	68.00
0.00	0.00	0.00	0.00	-1.00
-1.00	-0.09	0.44	90.00	90.00
65.00	9000.00	-9517.84	-3684.41	-59819.86
6001.95	-12053.46	1753.48	68.00	-1361.00
119.00	0.00	60000.00	-59820.00	1.95

2	68	15	61	0	0	-59677	-5860	885	90	0	200	59964

	68.00	0.00	1.00	
21.00	1.00	885.00	2.00	61307.28
-59676.88	-5860.10	0.00	1.00	68.00
0.00	0.00	0.00	0.00	-1.00
-1.00	0.03	0.44	90.00	90.00
65.00	9000.00	-6795.84	-3922.41	-59676.74
139.90	-9331.46	1515.48	68.00	1361.00
-119.00	0.00	60000.00	-59676.88	-5860.10

1	69	14	61	0	0	-58935	2	885	90	0	200	58935

	69.00	0.00	1.00	
12.00	1.00	885.00	2.00	57574.12
-58935.00	1.93	0.00	1.00	69.00
0.00	0.00	0.00	0.00	-1.00
-1.00	-0.09	0.44	90.00	90.00
65.00	9000.00	-9517.84	-3684.41	-58934.86
6001.93	-12053.46	1753.48	69.00	-1361.00
119.00	0.00	60000.00	-58935.00	1.93

12	69	0	0	0	0	-58935	2	885	90	0	200	57574

AIRCRAFT 1 AT RELEASE.

11	1	1	1	0	0	-58948	66	875	95	10	352	57587
2	69	16	62	0	0	-58792	-5860	885	90	0	200	59083

	69.00	0.00	1.00	
22.00	1.00	885.00	2.00	60426.23
-58791.88	-5860.11	0.00	1.00	69.00
0.00	0.00	0.00	0.00	-1.00
-1.00	0.03	0.44	90.00	90.00
65.00	9000.00	-6795.84	-3922.41	-58791.74
139.89	-9331.46	1515.48	69.00	1361.00
-119.00	0.00	60000.00	-58791.88	-5860.11

22	69	0	0	0	0	-58792	-5860	885	90	0	200	60426

AIRCRAFT 2 AT RELEASE.

21	1	1	1	0	0	-58805	-5796	875	88	10	352	60433
12	1	1	1	0	0	-58063	66	875	95	10	352	56702
1	70	15	62	0	0	-58050	2	893	98	0	200	58050
11	2	2	2	0	0	-58081	-11	870	95	10	503	56721
22	1	1	1	0	0	-57920	-5796	875	88	10	352	59552
2	70	17	63	0	0	-57907	-5860	893	98	0	200	58203
21	2	2	2	0	0	-57935	-5773	870	88	10	503	59565
12	2	2	2	0	0	-57197	-13	870	95	10	503	55836
1	71	16	63	0	0	-57167	-129	901	107	0	200	57167
11	3	3	3	0	0	-57220	-88	865	95	10	653	55859
22	2	2	2	0	0	-57050	-5772	870	98	10	503	58684

2	71	18	64	0	0	-57024	-5991	901	107	0	200	57337
21	3	3	3	0	0	-57071	-5749	865	88	10	653	58702
12	3	3	3	0	0	-56335	-91	865	95	10	653	54975
1	72	17	64	0	0	-56305	-392	909	116	0	200	56306
11	4	4	4	0	0	-56363	-164	860	95	0	653	55003
22	3	3	3	0	0	-56186	-5748	865	88	10	653	57821
2	72	19	65	0	0	-56162	-6255	909	116	0	200	56509
21	4	4	4	0	0	-56211	-5726	860	88	0	653	57844
12	4	4	4	0	0	-55479	-169	860	95	0	653	54118
1	73	18	65	0	0	-55485	-785	917	124	0	200	55491
11	5	5	5	0	0	-55512	-240	855	95	0	653	54152
22	4	4	4	0	0	-55326	-5724	860	88	0	653	56963
2	73	20	66	0	0	-55342	-6647	917	124	0	200	55740
21	5	5	5	0	0	-55356	-5702	855	88	0	653	56991
12	5	5	5	0	0	-54627	-246	855	95	0	653	53267
1	74	19	66	0	0	-54727	-1301	925	133	0	200	54743
11	6	6	6	0	0	-54665	-315	850	95	0	653	53306
22	5	5	5	0	0	-54471	-5701	855	88	0	653	56111
2	74	21	67	0	0	-54584	-7163	925	133	0	200	55052
21	6	6	6	0	0	-54507	-5679	850	88	0	653	56144
12	6	6	6	0	0	-53781	-322	850	95	0	653	52421
1	75	20	67	0	0	-54051	-1933	933	142	0	200	54086
11	7	7	7	0	0	-53823	-390	845	95	0	653	52465
22	6	6	6	0	0	-53622	-5677	850	88	0	653	55263
2	75	22	68	0	0	-53908	-7795	933	142	0	200	54469
21	7	7	7	0	0	-53662	-5656	845	88	0	653	55301
12	7	7	7	0	0	-52939	-399	845	95	0	653	51581
1	76	21	68	0	0	-53475	-2666	941	151	0	200	53541
11	8	8	8	0	0	-52987	-465	840	95	0	653	51629
22	7	7	7	0	0	-52777	-5653	845	88	0	653	54420
2	76	23	69	0	0	-53332	-8528	941	151	0	200	54009
21	8	8	8	0	0	-52822	-5633	840	88	0	653	54463
12	8	8	8	0	0	-52102	-475	840	95	0	653	50745
1	77	22	69	0	0	-53015	-3487	949	160	0	200	53130
11	9	9	9	0	0	-52155	-539	835	95	0	653	50798
22	8	8	8	0	0	-51937	-5630	840	88	0	653	53582
2	77	24	70	0	0	-52872	-9350	949	160	0	200	53692
21	9	9	9	0	0	-51987	-5610	835	88	0	653	53630
12	9	9	9	0	0	-51271	-550	835	95	0	653	49914
1	78	23	70	0	0	-52687	-4378	957	169	0	200	52868
11	10	10	10	0	0	-51328	-612	830	95	0	653	49973
22	9	9	9	0	0	-51103	-5607	835	88	0	653	52750
2	78	25	71	0	0	-52544	-10240	957	169	0	200	53532
21	10	10	10	0	0	-51158	-5587	830	88	0	653	52803
12	10	10	10	0	0	-50444	-625	830	95	0	653	49089
1	79	24	71	0	0	-52501	-5317	965	178	0	200	52770
11	11	11	11	0	0	-50506	-685	825	95	0	653	49152
22	10	10	10	0	0	-50273	-5584	830	88	0	653	51922
2	79	26	72	0	0	-52358	-11179	965	178	0	200	53538
21	11	11	11	0	0	-50333	-5563	825	88	0	653	51980
12	11	11	11	0	0	-49623	-699	825	95	0	653	48269
1	80	25	72	0	0	-52467	-6281	973	187	0	200	52842
11	12	12	12	0	0	-49690	-758	820	95	0	653	48337

22	11	11	11	0	0	-49448	[illegible]	825	88	0	653	51100
2	80	27	73	0	0	-52324	[illegible]	973	187	0	200	53714
21	12	12	12	0	0	-49513	43	820	88	0	653	51163
12	12	12	12	0	0	-48806	773	820	95	0	653	47453
1	81	26	73	0	0	-52588	-7246	981	196	0	200	53085
11	13	13	13	0	0	-48878	-830	815	95	0	653	47526
22	12	12	12	0	0	-48629	-5538	820	88	0	653	50282
2	81	28	74	0	0	-52445	-13108	981	196	0	200	54059
21	13	13	13	0	0	-48699	-5520	815	88	0	653	50350
12	13	13	13	0	0	-47994	-847	815	95	0	653	46643
1	82	27	74	0	0	-52867	-8187	989	206	0	200	53497
11	14	14	14	0	0	-48071	-902	810	95	0	653	46721
22	13	13	13	0	0	-47814	-5515	815	88	0	653	49470
2	82	29	75	0	0	-52723	-14049	989	206	0	200	54563
21	14	14	14	0	0	-47889	-5498	810	88	0	653	49543
12	14	14	14	0	0	-47188	-920	810	95	0	653	45838
1	83	28	75	0	0	-53297	-9077	997	215	0	200	54065
11	15	15	15	0	0	-47269	-973	805	95	0	653	45921
22	14	14	14	0	0	-47004	-5493	810	88	0	653	48663
2	83	30	76	0	0	-53154	-14939	997	215	0	200	55214
21	15	15	15	0	0	-47084	-5476	805	88	0	653	48741
12	15	15	15	0	0	-46386	-993	805	95	0	653	45039
1	84	29	76	0	0	-53873	-9891	1005	215	0	200	54774
11	16	16	16	0	0	-46472	-1044	800	95	0	653	45126
22	15	15	15	0	0	-46199	-5470	805	88	0	653	47861
2	84	31	77	0	0	-53730	-15753	1005	215	0	200	55992
21	16	16	16	0	0	-46285	-5454	800	88	0	653	47943
12	16	16	16	0	0	-45589	-1065	800	95	0	653	44244
1	85	30	77	0	0	-54454	-10712	1005	215	0	200	55497
11	17	17	17	0	0	-45680	-1114	795	95	0	653	44337
22	16	16	16	0	0	-45400	-5448	800	88	0	653	47063
2	85	32	78	0	0	-54311	-16574	1005	215	0	200	56783
21	17	17	17	0	0	-45490	-5433	795	88	0	653	47151
12	17	17	17	0	0	-44797	-1137	795	95	0	653	43455
1	86	31	78	0	0	-55034	-11532	1005	215	0	200	56229
11	18	18	18	0	0	-44894	-1184	790	95	0	653	43552
22	17	17	17	0	0	-44605	-5426	795	88	0	653	46271
2	86	33	79	0	0	-5489[illegible]	- 7394	1005	215	0	200	57581
21	18	18	18	0	0	-44700	3411	790	88	0	653	46364
12	18	18	18	0	0	-44011	-1208	790	95	0	653	42670
1	87	32	79	0	0	-55615	-12353	1005	215	0	200	56970
11	19	19	19	0	0	-44112	-1254	785	95	0	653	42773
22	18	18	18	0	0	-43815	-5404	790	88	0	653	45485
2	87	34	80	0	0	-55472	-18215	1005	215	0	200	58385
21	19	19	19	0	0	-43915	-5390	785	88	0	653	45582
12	19	19	19	0	0	-43229	-1279	785	95	0	653	41891
1	88	33	80	0	0	-56195	-1[illegible]173	1005	215	0	200	57718
11	20	20	20	0	0	-43335	-1323	780	95	0	653	41998
22	19	19	19	0	0	-43031	-5382	785	88	0	653	44703
2	88	35	81	0	0	-56052	-19035	1005	215	0	200	59196
21	20	20	20	0	0	-43136	-5368	780	88	0	653	44805
12	20	20	20	0	0	-42452	-1349	780	95	0	653	41117
1	89	34	81	0	0	-56776	-13993	1005	215	0	200	58475

11	21	21	21	0	0	-42563	-1392	775	95	0	653	41229
22	20	20	20	0	0	-42251	-5361	780	88	0	653	43926
2	89	36	82	0	0	-56632	-19855	1005	215	0	200	60012
21	21	21	21	0	0	-42361	-5347	775	88	0	653	44034
12	21	21	21	0	0	-41680	-1419	775	95	0	653	40349
1	90	35	82	0	0	-57356	-14814	1005	215	0	200	59238
11	22	22	22	0	0	-41796	-1460	770	95	0	653	40466
22	21	21	21	0	0	-41476	-5339	775	88	0	653	43154
2	90	37	83	0	0	-57213	-20676	1005	215	0	200	60834
21	22	22	22	0	0	-41591	-5326	770	88	0	653	43267
12	22	22	22	0	0	-40913	-1489	770	95	0	653	39585
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11	23	23	23	0	0	-41034	-1528	765	95	0	653	39707
22	22	22	22	0	0	-40707	-5318	770	88	0	653	42388
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21	23	23	23	0	0	-40827	-5305	765	88	0	653	42505
12	23	23	23	0	0	-40151	-1558	765	95	0	653	38827
1	92	37	84	0	0	-58317	-16455	1005	215	0	200	60786
11	24	24	24	0	0	-40277	-1595	760	95	0	653	38954
22	23	23	23	0	0	-39942	-5296	765	88	0	653	41626
2	92	39	85	0	0	-58374	-22317	1005	215	0	200	62494
21	24	24	24	0	0	-40067	-5284	760	88	0	653	41749
12	24	24	24	0	0	-39395	-1626	760	95	0	653	38074
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22	24	24	24	0	0	-39182	-5275	760	88	0	653	40870
2	93	40	86	0	0	-58954	-23137	1005	215	0	200	63332
21	25	25	25	0	0	-39312	-5264	755	88	0	653	40997
12	25	25	25	0	0	-38643	-1694	755	95	0	653	37326
1	94	39	86	0	0	-59678	-18096	1005	215	0	200	62361
11	26	26	26	0	0	-38778	-1728	750	95	0	653	37462
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2	94	41	87	0	0	-59535	-23958	1005	215	0	200	64174
21	26	26	26	0	0	-38563	-5243	750	88	0	653	40251
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1	95	40	87	0	0	-60258	-18916	1005	215	0	200	63158
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21	28	28	28	0	0	-37078	-5203	740	88	0	653	38774
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21	29	29	29	0	0	-36343	-5183	735	88	0	653	38043
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21	55	55	0	0	0	-14966	-4599	760	88	0	653	16931
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21	56	56	0	0	0	-14212	-4578	755	88	0	653	16198
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21	63	63	0	3	0	-7469	-4188	860	72	0	653	9722
12	63	63	0	5	2	-6553	-2261	870	65	10	1109	5712
1	132	0	124	0	0	-81735	-49272	1005	215	0	200	95438
11	64	64	0	6	2	-6453	-2194	860	65	10	1104	5593
22	63	63	0	4	2	-6666	-3860	855	65	0	653	8856
2	132	0	125	0	0	-81592	-55134	1005	215	0	200	98473
21	64	64	0	4	1	-6682	-3868	850	65	0	653	8874
12	64	64	0	6	3	-5769	-1896	865	65	0	1109	4847
1	133	0	125	0	0	-82316	-50092	1005	215	0	200	96359
11	65	65	0	7	3	-5678	-1833	855	65	0	1104	4738

22	64	64	0	5	3	-5896	-3501	850	65	10	801	8006
2	133	0	126	0	0	-82172	-55954	1005	215	0	200	99414
21	65	65	0	5	2	-5916	-3511	845	65	10	800	8029
12	65	65	0	7	4	-4990	-1532	860	65	0	1109	3987
1	134	0	126	0	0	-82896	-50913	1005	215	0	200	97282
11	66	66	0	8	4	-4908	-1474	850	65	0	1104	3888
22	65	65	0	6	4	-5130	-3144	845	65	10	948	7161
2	134	0	127	0	0	-82753	-56775	1005	215	0	200	100356
21	66	66	0	6	3	-5155	-3156	840	65	10	946	7189
12	66	66	0	8	5	-4215	-1171	855	65	0	1109	3132
1	135	0	127	0	0	-83477	-51733	1005	215	0	200	98207
11	67	67	0	9	5	-4142	-1117	845	65	0	1104	3043
22	66	66	0	7	5	-4369	-2789	840	65	10	1093	6321
2	135	0	128	0	0	-83333	-57595	1005	215	0	200	101300
21	67	67	0	7	4	-4398	-2803	835	65	10	1091	6354
12	67	67	0	9	6	-3444	-812	850	65	0	1109	2282
1	136	0	128	0	0	-84057	-52553	1005	215	0	200	99133
11	68	68	0	10	6	-3381	-762	840	65	0	1104	2203
22	67	67	0	8	6	-3612	-2436	835	65	10	1238	5486
2	136	0	129	0	0	-83914	-58415	1005	215	0	200	102244
21	68	68	0	8	5	-3646	-2452	830	65	10	1235	5524
12	68	68	0	10	7	-2678	-455	845	65	0	1109	1437
1	137	0	129	0	0	-84637	-53374	1005	215	0	200	100061
11	69	69	0	11	7	-2624	-409	835	65	0	1104	1369
22	68	68	0	9	7	-2860	-2085	830	65	0	1238	4656
2	137	0	130	0	0	-84494	-59236	1005	215	0	200	103190
21	69	69	0	9	6	-2898	-2104	825	65	0	1235	4699
12	69	69	0	11	8	-1917	-100	840	65	0	1109	598

WEAPON 12 AT DISPENSE.

1	138	0	130	0	0	-85218	-54194	1005	215	0	200	100991
11	70	70	0	12	8	-1872	-58	830	65	0	1104	540

WEAPON 11 AT DISPENSE.

22	69	69	0	10	8	-2112	-1736	825	65	0	1238	3831
2	138	0	131	0	0	-85075	-60056	1005	215	0	200	104137
21	70	70	0	10	7	-2155	-1757	820	65	0	1235	3879
1	139	0	131	0	0	-85798	-55015	1005	215	0	200	101921
22	70	70	0	11	9	-1369	-1390	820	65	0	1238	3011
2	139	0	132	0	0	-85655	-60877	1005	215	0	200	105085
21	71	71	0	11	8	-1417	-1413	815	65	0	1235	3064
1	140	0	132	0	0	-86379	-55835	1005	215	0	200	102854
22	71	71	0	12	10	-630	-1045	815	65	0	1238	2196
2	140	0	133	0	0	-86236	-61697	1005	215	0	200	106034
21	72	72	0	12	9	-682	-1070	810	65	0	1235	2254
1	141	0	133	0	0	-86959	-56655	1005	215	0	200	103787
22	72	72	0	13	11	104	-703	810	65	0	1238	1386
2	141	0	134	0	0	-86816	-62518	1005	215	0	200	106984
21	73	73	0	13	10	47	-730	805	65	0	1235	1449
1	142	0	134	0	0	-87540	-57476	1005	215	0	200	104722
22	73	73	0	14	12	834	-363	805	65	0	1238	581

WEAPON 22 AT DISPENSE.

2	142	0	135	0	0	-87397	-63338	1005	215	0	200	107935
21	74	74	0	14	11	772	-392	800	65	0	1235	649

WEAPON 21 AT DISPENSE.

1	143	0	135	0	0	-88120	-58296	1005	215	0	200	105658
2	143	0	136	0	0	-87977	-64158	1005	215	0	200	108886
1	144	0	136	0	0	-88701	-59117	1005	215	0	200	106595
2	144	0	137	0	0	-88557	-64979	1005	215	0	200	109839
1	145	0	137	0	0	-89281	-59937	1005	215	0	200	107534
2	145	0	138	0	0	-89138	-65799	1005	215	0	200	110793
1	146	0	138	0	0	-89861	-60758	1005	215	0	200	108474
2	146	0	139	0	0	-89718	-66620	1005	215	0	200	111748
1	147	0	139	0	0	-90442	-61578	1005	215	0	200	109415
2	147	0	140	0	0	-90299	-67440	1005	215	0	200	112703
1	148	0	140	0	0	-91022	-62398	1005	215	0	200	110357
2	148	0	141	0	0	-90879	-68261	1005	215	0	200	113660
1	149	0	141	0	0	-91603	-63219	1005	215	0	200	111300
2	149	0	142	0	0	-91460	-69081	1005	215	0	200	114617
1	150	0	142	0	0	-92183	-64039	1005	215	0	200	112244
2	150	0	143	0	0	-92040	-69901	1005	215	0	200	115575
1	151	0	143	0	0	-92764	-64860	1005	215	0	200	113190
2	151	0	144	0	0	-92621	-70722	1005	215	0	200	116534
1	152	0	144	0	0	-93344	-65680	1005	215	0	200	114136
2	152	0	0	0	0	-93201	-71542	1005	215	0	200	117494
1	153	0	0	0	0	-93925	-66501	1005	215	0	200	115083
2	153	0	0	0	0	-93782	-72363	1005	215	0	200	118454
1	154	0	1	0	0	-94505	-67321	1005	215	0	200	116032
2	154	0	0	0	0	-94362	-73183	1005	215	0	200	119415
1	155	0	2	0	0	-95086	-68141	1005	215	0	200	116981
2	155	0	0	0	0	-94942	-74003	1005	215	0	200	120377
1	156	0	0	0	0	-95666	-68962	1005	215	0	200	117931
1	157	0	0	0	0	-96246	-69782	1005	215	0	200	118882
1	158	0	0	0	0	-96827	-70603	1005	215	0	200	119834
1	159	0	0	0	0	-97407	-71423	1005	215	0	200	120787

Appendix H: Conventional Delivery Maneuvers

1. Level Delivery Maneuver Flown From a 090 Entry.

		-- THREATS --				COORDINATES						
ID	TOF	1	2	3	4	X	Y	VEL	HDG	P	ALT	RANGE
						[INGRESS]						
1	118	63	0	0	0	-15570	103	885	90	0	200	14209
2	118	65	0	0	0	-15544	-921	885	87	0	200	16924
1	119	64	0	0	0	-14685	104	885	90	0	200	13324
2	119	66	0	0	0	-14660	-880	885	87	0	200	16039
1	120	65	0	0	0	-13800	105	885	90	0	200	12439
2	120	67	0	0	0	-13776	-838	885	87	0	200	15154
1	121	66	0	0	0	-12915	106	885	90	0	200	11554
2	121	68	0	0	0	-12892	-796	885	87	0	200	14269
1	122	67	0	0	0	-12030	107	885	90	0	200	10669
2	122	69	0	0	0	-12008	-754	885	87	0	200	13384
1	123	68	0	0	0	-11145	108	875	90	10	354	9784
2	123	70	0	1	0	-11124	-712	885	87	0	200	12499
1	124	69	0	1	0	-10283	108	865	90	10	506	8922
2	124	71	0	2	0	-10240	-670	885	87	0	200	11614
1	125	70	0	2	0	-9431	109	855	90	10	656	8070
2	125	72	0	3	0	-9356	-628	885	87	0	200	10729
1	126	71	0	3	0	-8589	110	855	90	0	750	7228
2	126	73	0	4	0	-8472	-587	875	87	10	354	9844
1	127	72	0	4	1	-7734	111	855	90	0	750	6373
2	127	74	0	5	1	-7611	-546	865	87	10	506	8982
1	128	73	0	5	2	-6879	112	855	90	0	750	5518
		AIRCRAFT 1 AT RELEASE.										
2	128	75	0	6	2	-6760	-506	855	87	10	656	8130
1	129	74	0	6	3	-6024	112	873	98	-10	602	4663
2	129	76	0	7	3	-5919	-466	855	87	0	750	7288
1	130	75	0	7	4	-5173	-9	891	106	-10	450	3814
2	130	77	0	8	4	-5065	-425	855	87	0	750	6433
1	131	76	0	8	5	-4332	-257	909	115	-10	295	2994
2	131	78	0	9	5	-4211	-385	855	87	0	750	5578
		AIRCRAFT 2 AT RELEASE.										
1	132	77	0	9	6	-3520	-635	927	124	0	200	2287
2	132	79	0	10	6	-3357	-344	873	95	-10	602	4723
1	133	78	0	10	7	-2748	-1149	935	132	0	200	1879
2	133	80	0	11	7	-2501	-426	891	104	-10	450	3874
1	134	79	0	11	8	-2059	-1780	943	141	0	200	2023
2	134	81	0	12	8	-1649	-635	909	112	-10	295	3054
1	135	80	0	12	9	-1471	-2517	951	150	0	200	2639
2	135	82	0	13	9	-821	-975	927	121	0	200	2344
1	136	81	0	13	10	-1001	-3344	959	160	0	200	3482
2	136	83	0	14	10	-26	-1452	935	130	0	200	1924
1	137	82	0	14	11	-666	-4243	967	169	0	200	4417
2	137	84	0	15	11	692	-2051	943	139	0	200	2045
1	138	83	0	15	12	-476	-5191	975	178	0	200	5383

2	138	85	0	16	12	1314	-2760	951	148	0	200	2642
1	139	84	0	16	13	-440	-6165	983	187	0	200	6351
2	139	86	0	17	13	1821	-3565	959	157	0	200	3476
1	140	85	0	17	14	-563	-7140	991	197	0	200	7303
2	140	87	0	18	14	2198	-4447	967	166	0	200	4408
1	141	86	0	18	15	-847	-8090	999	206	0	200	8225
2	141	88	0	19	15	2432	-5385	975	175	0	200	5374
1	142	87	0	19	0	-1286	-8988	1007	216	0	200	9107
2	142	89	0	20	16	2512	-6357	983	185	0	200	6343
1	143	88	0	20	0	-1872	-9806	1007	216	0	200	9938
2	143	90	0	21	17	2434	-7337	991	194	0	200	7297
1	144	89	0	0	0	-2458	-10625	1007	216	0	200	10800
2	144	91	0	22	18	2195	-8298	999	203	0	200	8222
1	145	90	0	0	0	-3044	-11444	1007	216	0	200	11685
2	145	92	0	23	0	1799	-9215	1007	213	0	200	9107
1	146	91	0	0	0	-3631	-12262	1007	216	0	200	12588
2	146	93	0	0	0	1251	-10060	1007	213	0	200	9942

[EGRESS]

2. <u>Toss Delivery Maneuver Flown From a 090 Entry</u>.

		-- THREATS --				COORDINATES						
ID	TOF	1	2	3	4	X	Y	VEL	HDG	P	ALT	RANGE
						[INGRESS]						
1	96	41	88	0	0	-35040	85	885	90	0	200	33679
2	96	43	89	0	0	-34992	-1842	885	87	0	200	36394
1	97	42	89	0	0	-34155	85	885	90	0	200	32794
2	97	44	90	0	0	-34108	-1800	885	87	0	200	35509
1	98	43	90	0	0	-33270	86	885	90	0	200	31909
2	98	45	91	0	0	-33224	-1758	885	87	0	200	34624
1	99	44	91	0	0	-32385	87	885	90	0	200	31024
2	99	46	92	0	0	-32340	-1716	885	87	0	200	33739
1	100	45	92	0	0	-31500	88	885	90	0	200	30139
2	100	47	93	0	0	-31456	-1675	885	87	0	200	32854
1	101	46	93	0	0	-30615	89	880	90	5	277	29254
2	101	48	94	0	0	-30572	-1633	885	87	0	200	31969
1	102	47	94	0	0	-29738	90	870	90	10	430	28377
2	102	49	95	0	0	-29688	-1591	885	87	0	200	31084
1	103	48	95	0	0	-28882	90	855	90	15	655	27521
2	103	50	96	0	0	-28804	-1549	885	87	0	200	30199
1	104	49	96	0	0	-28056	91	835	90	20	947	26695
2	104	51	97	0	0	-27920	-1507	880	87	5	277	29314
1	105	50	97	0	0	-27271	92	810	90	25	1300	25910
2	105	52	98	0	0	-27044	-1466	870	87	10	430	28437
1	106	51	98	0	0	-26537	93	780	90	30	1705	25176
2	106	53	99	0	0	-26188	-1425	855	87	15	655	27580
1	107	52	99	0	0	-25861	93	745	90	35	2153	24500

2	107	54	100	0	0	-25363	-1386	835	87	20	947	26754
1	108	53	100	0	0	-25251	94	705	90	40	2632	23890
2	108	55	101	0	0	-24580	-1349	810	87	25	1300	25970
1	109	54	101	0	0	-24711	94	660	90	45	3130	23350
2	109	56	102	0	0	-23846	-1314	780	87	30	1705	25236
1	110	55	102	0	0	-24244	95	615	90	45	3597	22883
		AIRCRAFT 1 AT RELEASE.										
2	110	57	103	0	0	-23172	-1282	745	87	35	2153	24560
1	111	56	103	0	0	-23810	95	583	96	40	3992	22449
2	111	58	104	0	0	-22562	-1254	705	87	40	2632	23950
1	112	57	104	0	0	-23365	50	556	101	35	4326	22004
2	112	59	105	0	0	-22023	-1228	660	87	45	3130	23410
1	113	58	105	0	0	-22919	-40	534	107	30	4604	21558
2	113	60	106	0	0	-21556	-1206	615	87	45	3597	22943
		AIRCRAFT 2 AT RELEASE.										
1	114	59	106	0	0	-22476	-173	517	112	25	4830	21117
2	114	61	107	0	0	-21122	-1185	583	93	40	3992	22508
1	115	60	107	0	0	-22041	-347	505	117	20	5007	20685
2	115	62	108	0	0	-20676	-1210	556	99	35	4326	22064
1	116	61	108	0	0	-21617	-560	498	122	15	5137	20267
2	116	63	0	0	0	-20226	-1279	534	104	30	4604	21618
1	117	62	109	0	0	-21207	-812	496	126	10	5224	19868
2	117	64	0	0	0	-19777	-1391	517	109	25	4830	21177
1	118	63	110	0	0	-20813	-1101	499	131	5	5267	19491
2	118	65	0	0	0	-19335	-1545	505	114	20	5007	20745
1	119	64	0	0	0	-20439	-1428	507	136	0	5267	19140
2	119	66	0	0	0	-18901	-1739	498	119	15	5137	20327
1	120	65	0	0	0	-20085	-1791	520	141	-5	5223	18821
2	120	67	0	0	0	-18480	-1971	496	124	10	5224	19928
1	121	66	0	0	0	-19757	-2192	538	146	-10	5133	18540
2	121	68	0	0	0	-18074	-2242	499	128	5	5267	19550
1	122	67	0	0	0	-19458	-2629	561	151	-15	4993	18304
2	122	69	0	0	0	-17684	-2551	507	133	0	5267	19200
1	123	68	0	0	0	-19193	-3102	589	156	-20	4802	18120
2	123	70	0	0	0	-17314	-2897	520	138	-5	5223	18881
1	124	69	0	0	0	-18969	-3608	617	162	-20	4600	17998
2	124	71	0	0	0	-16968	-3282	538	143	-10	5133	18600
1	125	70	0	0	0	-18787	-4159	645	168	-20	4389	17944
2	125	72	0	0	0	-16649	-3705	561	148	-15	4993	18363
1	126	71	0	0	0	-18657	-4751	673	174	-20	4169	17969
2	126	73	0	0	0	-16362	-4165	589	153	-20	4802	18179
1	127	72	0	0	0	-18589	-5379	701	180	-20	3938	18084
2	127	74	0	0	0	-16115	-4661	617	159	-20	4600	18056
1	128	73	0	0	0	-18592	-6038	729	187	-20	3699	18298
2	128	75	0	0	0	-15908	-5202	645	165	-20	4389	18002
1	129	74	0	0	0	-18674	-6718	757	194	-20	3449	18614
2	129	76	0	0	0	-15751	-5788	673	171	-20	4169	18026
1	130	75	0	0	0	-18845	-7409	785	201	-20	3190	19035
2	130	77	0	0	0	-15654	-6412	701	178	-20	3938	18141
1	131	76	0	0	0	-19110	-8097	813	209	-20	2922	19559
2	131	78	0	0	0	-15626	-7071	729	184	-20	3699	18354
1	132	77	0	0	0	-19476	-8768	841	216	-20	2644	20177
2	132	79	0	0	0	-15677	-7754	757	191	-20	3449	18670
1	133	78	0	0	0	-19945	-9404	869	216	-20	2356	20882

2	133	80	0	0	0	-15815	-8451	785	198	-20	3190	19090
1	134	79	0	0	0	-20429	-10061	892	216	-15	2131	21616
2	134	81	0	0	0	-16048	-9151	813	206	-20	2922	19613
1	135	80	1	0	0	-20940	-10755	915	216	-15	1901	22396
2	135	82	0	0	0	-16383	-9838	841	214	-20	2644	20231
1	136	81	2	0	0	-21464	-11467	938	216	-15	1664	23203
2	136	83	0	0	0	-16821	-10495	869	214	-20	2356	20935
1	137	82	3	0	0	-22001	-12196	961	216	-15	1421	24035
2	137	84	0	0	0	-17275	-11175	892	214	-15	2131	21668
1	138	83	4	0	0	-22552	-12944	984	216	-15	1172	24894
2	138	85	0	0	0	-17753	-11891	915	214	-15	1901	22448
1	139	84	5	0	0	-23115	-13709	1007	216	-15	918	25777
2	139	86	0	0	0	-18244	-12627	938	214	-15	1664	23255
1	140	85	6	0	0	-23692	-14492	1022	216	-15	657	26687
2	140	87	0	0	0	-18746	-13380	961	214	-15	1421	24087
1	141	86	7	0	0	-24278	-15287	1032	216	-10	480	27614
2	141	88	1	0	0	-19262	-14152	984	214	-15	1172	24944
1	142	87	8	0	0	-24880	-16106	1037	216	-5	390	28573
2	142	89	2	0	0	-19789	-14943	1007	214	-15	918	25828
1	143	88	9	0	0	-25493	-16937	1037	216	0	390	29551
2	143	90	3	0	0	-20329	-15752	1022	214	-15	657	26737
1	144	89	10	0	0	-26108	-17772	1037	216	0	390	30537
2	144	91	4	0	0	-20877	-16573	1032	214	-10	480	27664
1	145	90	11	0	0	-26723	-18607	1037	216	0	390	31526
2	145	92	5	0	0	-21441	-17419	1037	214	-5	390	28622
1	146	91	12	0	0	-27338	-19442	1037	216	0	390	32518
2	146	93	6	0	0	-22015	-18278	1037	214	0	390	29600
1	147	92	13	0	0	-27953	-20277	1037	216	0	390	33513
2	147	94	7	0	0	-22590	-19140	1037	214	0	390	30596
1	148	93	14	0	0	-28568	-21112	1037	216	0	390	34510
2	148	95	8	0	0	-23166	-20003	1037	214	0	390	31574
1	149	94	15	0	0	-29182	-21947	1037	216	0	390	35510
2	149	96	9	0	0	-23741	-20866	1037	214	0	390	32566
1	150	95	16	0	0	-29797	-22782	1037	216	0	390	36512
2	150	97	10	0	0	-24317	-21728	1037	214	0	390	33561

[EGRESS]

3. <u>LALD Delivery Maneuver Flown From a 090 Entry.</u>

-- THREATS --				COORDINATES								
ID	TOF	1	2	3	4	X	Y	VEL	HDG	P	ALT	RANGE
						[INGRESS]						
1	108	53	100	0	0	-24420	95	885	90	0	200	23059
2	108	55	101	0	0	-24384	-1340	885	87	0	200	25774
1	109	54	101	0	0	-23535	96	885	90	0	200	22174
2	109	56	102	0	0	-23500	-1298	885	87	0	200	24889
1	110	55	102	0	0	-22650	96	885	100	0	200	21289

2	110	57	103	0	0	-22616	-1256	885	87	0	200	24004
1	111	56	103	0	0	-21778	-56	885	110	0	200	20418
2	111	58	104	0	0	-21732	-1214	885	87	0	200	23119
1	112	57	104	0	0	-20946	-358	885	120	0	200	19591
2	112	59	105	0	0	-20848	-1172	885	87	0	200	22234
1	113	58	0	0	0	-20180	-800	875	120	10	354	18841
2	113	60	0	0	0	-19964	-1131	885	97	0	200	21349
1	114	59	0	0	0	-19433	-1230	855	120	20	653	18122
2	114	61	0	0	0	-19086	-1243	885	107	0	200	20478
1	115	60	0	0	0	-18737	-1631	835	120	20	945	17464
2	115	62	0	0	0	-18241	-1506	885	117	0	200	19651
1	116	61	0	0	0	-18057	-2023	815	120	20	1231	16833
2	116	63	0	0	0	-17454	-1912	875	117	10	354	18901
1	117	62	0	0	0	-17393	-2405	795	120	20	1510	16230
2	117	64	0	0	0	-16689	-2307	855	117	20	653	18182
1	118	63	0	0	0	-16746	-2778	775	120	20	1782	15655
2	118	65	0	0	0	-15975	-2675	835	117	20	945	17523
1	119	64	0	0	0	-16115	-3142	755	120	20	2047	15110
2	119	66	0	0	0	-15277	-3035	815	117	20	1231	16892
1	120	65	0	0	0	-15500	-3496	735	120	20	2305	14594
2	120	67	0	0	0	-14597	-3386	795	117	20	1510	16289
1	121	66	0	0	0	-14902	-3841	715	120	20	2556	14108
2	121	68	0	0	0	-13933	-3729	775	117	20	1782	15714
1	122	67	0	0	0	-14319	-4176	699	110	16	2748	13652
2	122	69	0	0	0	-13286	-4062	755	117	20	2047	15168
1	123	68	0	0	0	-13686	-4406	688	100	11	2884	13129
2	123	70	0	0	0	-12655	-4388	735	117	20	2305	14652
1	124	69	0	0	0	-13021	-4522	681	90	7	2966	12550
2	124	71	0	0	0	-12041	-4704	715	117	20	2556	14165
1	125	70	0	0	0	-12345	-4522	679	80	2	2994	11924
2	125	72	0	0	0	-11444	-5013	699	107	16	2748	13708
1	126	71	0	0	0	-11677	-4403	681	70	-2	2971	11263
2	126	73	0	1	0	-10801	-5213	688	97	11	2884	13186
1	127	72	0	1	0	-11037	-4170	687	60	-6	2895	10584
2	127	74	0	2	0	-10131	-5298	681	87	7	2966	12606
1	128	73	0	2	0	-10446	-3828	698	67	-11	2766	9905
2	128	75	0	3	0	-9456	-5266	679	77	2	2994	11979
1	129	74	0	3	0	-9817	-3554	713	67	-15	2583	9219
2	129	76	0	4	0	-8794	-5117	681	67	-2	2971	11318
1	130	75	0	4	0	-9186	-3280	729	67	-15	2396	8531
2	130	77	0	5	0	-8166	-4854	687	57	-6	2895	10639
1	131	76	0	5	0	-8541	-3000	744	67	-15	2205	7828
2	131	78	0	6	0	-7591	-4485	698	64	-11	2766	9960
1	132	77	0	6	1	-7882	-2714	759	67	-15	2010	7110
2	132	79	0	7	1	-6975	-4185	713	64	-15	2583	9274
1	133	78	0	7	2	-7211	-2422	774	67	-15	1811	6378
2	133	80	0	8	2	-6356	-3883	729	64	-15	2396	8586
1	134	79	0	8	3	-6525	-2125	789	67	-15	1608	5631
		AIRCRAFT 1 AT RELEASE.										
2	134	81	0	9	3	-5724	-3575	744	64	-15	2205	7883
1	135	80	0	9	4	-5827	-1821	807	59	-10	1471	4869
2	135	82	0	10	4	-5079	-3260	759	64	-15	2010	7165
1	136	81	0	10	5	-5145	-1411	825	51	-10	1331	4082
2	136	83	0	11	5	-4421	-2939	774	64	-15	1811	6433

1	137	82	0	11	6	-4511	-903	843	43	-10	1187	3312
2	137	84	0	12	6	-3749	-2611	789	64	-15	1608	5685
		AIRCRAFT 2 AT RELEASE.										
1	138	83	0	12	7	-3940	-299	861	35	-10	1041	2613
2	138	85	0	13	7	-3064	-2277	807	56	-10	1471	4924
1	139	84	0	13	8	-3450	393	879	27	-10	891	2107
2	139	86	0	14	8	-2402	-1838	825	49	-10	1331	4137
1	140	85	0	14	9	-3055	1164	897	19	-10	738	1991
2	140	87	0	15	9	-1790	-1302	843	41	-10	1187	3366
1	141	86	0	15	10	-2772	2001	915	10	-10	583	2352
2	141	88	0	16	10	-1247	-674	861	33	-10	1041	2666
1	142	87	0	16	11	-2613	2888	933	1	-10	424	3039
2	142	89	0	17	11	-787	39	879	25	-10	891	2154
1	143	88	0	17	12	-2591	3807	951	352	-10	262	3388
2	143	90	0	18	12	-427	826	897	16	-10	738	2022
1	144	89	0	18	13	-2713	4736	969	343	0	200	4811
2	144	91	0	19	13	-180	1675	915	8	-10	583	2365
1	145	90	0	19	14	-2990	5665	977	334	0	200	5781
2	145	92	0	20	14	-61	2569	933	359	-10	424	3041
1	146	91	0	20	15	-3416	6545	985	325	0	200	6746
2	146	93	0	21	15	-79	3488	951	350	-10	262	3883
1	147	92	1	21	16	-3984	7350	993	315	0	200	7692
2	147	94	0	22	16	-242	4410	969	341	0	200	4805
1	148	93	2	22	17	-4682	8057	1001	306	0	200	8605
2	148	95	1	23	17	-560	5326	977	332	0	200	5774
1	149	94	3	0	0	-5493	8645	1001	306	0	200	9474
2	149	96	2	24	18	-1024	6186	985	322	0	200	6741
1	150	95	4	0	0	-6304	9232	1001	306	0	200	10367
2	150	97	3	25	19	-1627	6966	993	313	0	200	7689
1	151	96	5	0	0	-7115	9819	1001	306	0	200	11279
2	151	98	4	26	20	-2355	7642	1001	303	0	200	8604
1	152	97	6	0	0	-7926	10407	1001	306	0	200	12204
2	152	99	5	27	21	-3191	8193	1001	303	0	200	9477

[EGRESS]

Appendix I: AAP Damage Expectancy Estimates

Damage Expectancy	CEP	Attack Angle	Pattern Length
0.65	100	5	500
0.76	100	30	500
0.73	100	45	500
0.72	100	60	500
0.73	100	85	500
0.62	100	5	600
0.70	100	30	600
0.68	100	45	600
0.65	100	60	600
0.53	100	85	600
0.61	100	5	700
0.64	100	30	700
0.61	100	45	700
0.58	100	60	700
0.41	100	85	700
0.30	200	5	500
0.41	200	30	500
0.39	200	45	500
0.43	200	60	500
0.49	200	85	500
0.30	200	5	600
0.43	200	30	600
0.38	200	45	600
0.40	200	60	600
0.40	200	85	600
0.29	200	5	700
0.36	200	30	700
0.39	200	45	700
0.41	200	60	700
0.31	200	85	700
0.18	300	5	500
0.25	300	30	500
0.24	300	45	500
0.23	300	60	500
0.27	300	85	500
0.19	300	5	600
0.23	300	30	600
0.24	300	45	600
0.24	300	60	600
0.20	300	85	600
0.19	300	5	700
0.21	300	30	700
0.22	300	45	700
0.22	300	60	700
0.19	300	85	700

Appendix J: Standoff Weapon Attrition Data

Release Point Deg/NM	Threats: Current SAM	Outyear SAM	AAA 1	AAA 2	Total
150/20	0/36	4/84	9/1179	9/1183	22/800
/15	1/39	5/99	17/1143	13/1142	36/800
/10	1/18	3/45	7/1172	7/1170	18/792
/ 5	0/16	0/19	10/1144	12/1140	22/752
120/20	1/38	12/78	12/1172	8/1177	33/800
/15	0/37	11/71	13/1153	13/1143	37/800
/10	2/28	3/39	14/1161	8/1127	27/790
/ 5	0/11	1/14	9/1157	8/1133	18/760
090/20	0/43	10/79	6/1182	15/1159	31/800
/15	2/37	15/71	7/1179	6/1154	30/800
/10	2/26	3/35	6/1146	9/1099	20/772
/ 5	0/14	0/03	13/1151	12/1083	25/764
060/20	2/37	9/72	10/1177	14/1160	35/800
/15	0/29	11/70	15/1151	8/1151	34/799
/10	0/25	6/29	11/1156	9/1104	25/780
/ 5	0/15	1/07	11/1162	11/1104	23/748
030/20	2/30	12/81	6/1184	13/1168	33/800
/15	0/45	8/76	17/1116	14/1020	39/800
/10	0/23	2/36	14/1150	8/1147	24/772
/ 5	0/10	0/03	9/1169	9/1082	18/742

(Kills/Engagements)

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Major Dennis M. Coulter was born on 14 November 1949 in Pensacola, Florida. He graduated from high school in Tustin, California, in 1968 and attended the California State University at Fullerton from which he received the degree of Bachelor of Science in Mechanical Engineering in June 1972. Upon graduation, he received a commission in the USAF through the ROTC program. He attended Undergraduate Pilot Training at Laughlin AFB, Texas, and received his wings in November 1973. He then served as an F-111F Pilot Weapons Systems Officer at Mountain Home AFB, Idaho, until upgrade to Aircraft Commander in August 1976. In 1977 he was transferred to RAF Lakenheath, England, and served as an Instructor Pilot, Squadron Weapons Officer, and Assistant Flight Commander. He entered the rated supplement in 1980 and served as a Weapons Design Engineer at the Air Force Armament Laboratory, Eglin AFB, Florida, until 1982. At that time, he returned to flying duties in the F-111D as an Instructor Pilot and Flight Commander at Cannon AFB, New Mexico. He entered the School of Engineering, Air Force Institute of Technology in August 1984. He is a senior pilot with over 2000 hours.

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VITA

Captain Douglas W. Fry was born on 4 March 1954 in Denver, Colorado. He graduated from high school in Scott City, Kansas, in 1972 and attended the United States Air Force Academy. In June 1976 he graduated from the academy with a Bachelor of Science degree in Mathematics and also received his commission in the USAF. After graduation, he entered Titan Missile training which he completed in March 1977 with a follow-on assignment to the 571st Missile Squadron at Davis-Monthan AFB, Arizona. He served as a Deputy Combat Missile Commander until May 1979 when he upgraded to Crew Commander. After tour completion in June 1981 he was assigned to the 7361st Munitions Support Squadron in Belgium as the Chief of Operations. He held that position until entering the School of Engineering, Air Force Institute of Technology, in August 1984.

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